MISSILES AND ROCKETS

Magazine of World Astronautics

Volume 1

1956

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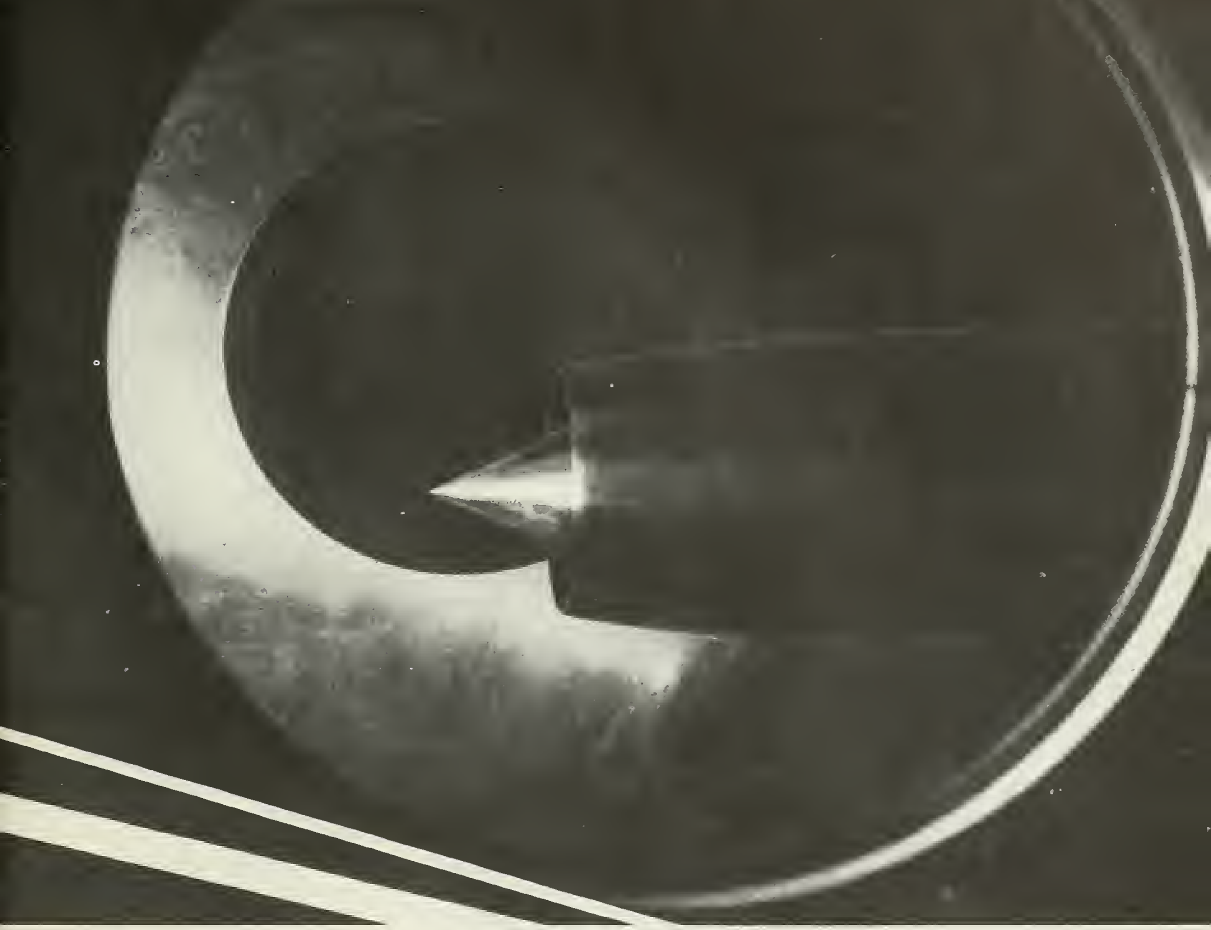

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

IN THIS ISSUE: DR. WERNHER VON BRAUN • DR. HUGH L. DRYDEN • KURT R. STEHLING • LOVELL LAWRENCE JR. • VANGUARD SATELLITE IN PICTURES •

missiles and rockets

Magazine of World Astronautics

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A New Age Unfolds

THIS IS THE AGE OF ASTRONAUTICS. This is the beginning of the unfolding of the era of space flight. This is to be the most revealing and the most fascinating age since man first inhabited the earth.

Shortly the first satellite vehicles will be hurtled aloft by powerful rockets to bring back the known from the unknown. Out of the coming conquest of space will come scientific data that will benefit the whole world. There will be advances in the fields of meteorology, flight safety, medicine, physics and many others. The possibilities are without limit.

The visionaries who long ago dreamed of the conquest of space have been succeeded by scientists and industrialists who have transformed a fantasy into a vast and important industry combining the needs of defense with a search for peaceful uses of space vehicles.

Rocketry has come a long way since the time less than twenty years ago when Adolf Hitler and his close associate Heinrich Himmler were skeptical of the efforts being exerted by German scientists to build huge and costly rockets for upper air research. But the impact of the first V-1s and V-2s which fell on London was not lost on the scientists of the world. Today the rocket—or a rocket weapon—is being openly discussed as perhaps the ultimate weapon for the prevention of war. Perhaps it will be the last weapon of war.

The age of astronautics, as has been true with so many scientific advances, leans heavily upon the military in these early stages. But a great amount of research and development must come from scientific institutions and industry. A prime example of the frontal approach now being made is the Vanguard Satellite Program utilizing an amazing combination of talent from both military and scientific organizations.

A measure of the rapid expansion in the entire missiles field is the increase in expenditures by the Department of Defense alone from $21 million in fiscal 1951 to $1.3 billion in the current fiscal year. But this is only a part of the over-all total.

It is our purpose to serve this new and growing field of missiles, rockets, satellites and astronautics to the best of our ability and within the limitations of national security. Rigid though certain security restrictions may be, there is a vast amount of unclassified material available.

The official journal of the American Rocket Society, *Jet Propulsion*, is performing an excellent technical service. It is our purpose to supplement its valuable work with a news and feature periodical geared to the growing industrial, government and scientific requirements of what is today a complete new industry.

To ensure political quality, we have support without peer. Mr. Robert H. Wood, for eighteen years a top aviation editor, will supervise this magazine as editorial director for the company. Mr. Erik Bergaust, a recognized authority in the field of astronautics, is managing editor. In the background is an editorial board of world renowned scientists. We shall spare no effort to make MISSILES & ROCKETS a magazine that fulfills the interests and needs of all who believe that they are, indeed, embarking on another great adventure in the history of mankind.

WAYNE W. PARRISH
President and Publisher

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missiles and rockets
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the Cover Picture

Extensive missile research in NACA's 4 x 4-foot supersonic pressure tunnel at Langley Aeronautical Laboratory has yielded a substantial amount of data for the industry. The fact that NACA has been actively engaged in missile and rocket research has not been widely publicized; MISSILES & ROCKETS *asked Dr. Hugh L. Dryden to outline NACA's role in this respect. His article appears on page 44.*

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PHOTO CREDITS:
NACA, Front Cover; U.S. Navy, pp. 11, 15; McDonnell, p. 16; Northrop, p. 24; Curtiss-Wright, p. 28; Bristol, p. 37; U.S. Army, pp. 39, 40, 41, 42, 43; NACA, pp. 45, 46, 47; U.S. Navy, pp. 64, 68, 69, 70; Univ. of Tokyo; pp. 92, 94; Fairey, p. 100; Harris & Ewing, p. 116; Bell, p. 116.

Army to Launch 'Satellite' Before Vanguard?

Defense Research Officials Disturbed

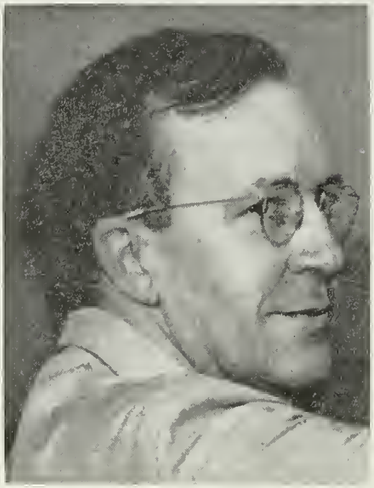
Army Ordnance rocket experts are quietly planning to launch what may become an Earth-circling "satellite" of their own—long before the Navy Vanguard is ready to go, MISSILES & ROCKETS has learned.

But the Army's plans for an "accidental" satellite aren't secret from high officials of the Office of Research and Development in the Defense Department. What's more, these officials make it clear they don't like the Army plan and that the soldiers have no authorization to launch a satellite.

Be that as it may, no one disputes that the Army possesses the raw capability of boosting a small rocket up to orbital velocity. This could be achieved with a *Redstone* rocket as the first stage, a *Sergeant* or some other ballistic rocket as a second stage and a small solid-propellant rocket as the third stage which would become an orbiter.

Thus, the potential does exist, and the current series of *Redstone* tests at Patrick AFB, Fla. may see the feat performed. Whether it works or not, however, it should be observed that a satellite would be merely incidental to the Army's basic desire to learn more about the staging techniques of tomorrow's ballistic missiles.

● **The three-step principle** is familiar to Redstone rocket scientists, but previously it has only been applied to small missiles. In order to learn more about the separation of stages for larger ballistic missiles the Army can well justify the "satellite experiment." In other words, the fact that a small uninstrumented body might be placed in an orbit around the earth is quite incidental and not so much of importance to the Army as is the valuable information it could obtain on separation of one missile from another.



VANGUARD'S JOHN P. HAGEN
Army coming from behind.

Although the Army "satellite" will be sort of appropos, if successfully launched, such experiments certainly will yield terrific prestige; after all, the Army was called upon originally to handle the hardware stage of the first Office of Naval Research satellite project, Project Orbiter, which was blended into the later Project Vanguard.

When asked whether Army Ordnance is planning to put up a "satellite," an Army spokesman told MISSILES & ROCKETS: "No comment"—but he said it with a smile.

An independent rocket propulsion expert was more definite: "Certainly, the Army has got hardware powerful enough to send a substantial payload to the moon!"

Meanwhile, the Naval Research Laboratory is struggling with the world's first instrumented satellite (first—provided the Russians don't beat us to it).

● **Vanguard project director** Dr. John P. Hagen claims his venture is moving along according to schedule. Because it is basically a crash program, many NRL scientists and technicians work overtime to meet the deadline. The magnitude of Project Vanguard is very great indeed; obviously the Vanguard engineers do not have much time to worry about possible "competition" from the Army.

Incidentally, the Army's interest in actual satellites as such is not a new thing. It will be recalled that astronomer Clyde Tombaugh was granted an Army Ordnance contract some time ago to find out whether the earth already has a tiny, natural satellite. Tombaugh has not yet found any satellite, but if he does, Army thinking is that such a small celestial body (or bodies, possibly) might be useful for tracking purposes.

As a matter of fact, Tombaugh is currently planning to set up an observation post in Peru close to the equator, whereupon possibilities for finding the natural satellite, if any, will be substantially increased.

180-Mile Altitude Seen For Rocket Aircraft

North American is developing a manned rocket aircraft which will be capable of reaching an altitude of 180 miles, according to NAA test pilot George Smith.

He did not identify the aircraft, but it was believed he was referring to North American's X-15 experimental rocket aircraft. This machine has been said to have a preliminary capability of 50 miles and eventually 150 miles.

Smith is the first man known to have survived a supersonic bailout. He spent six months in the hospital after ejecting from an F-100 just off the coast of California.

Army Policy Statement Reveals Aim To Acquire Control of IRBM

In a forthright bid to gain control of the intermediate-range ballistic missile, the Army has issued a formal policy statement declaring flatly that its tactical requirements include long-range surface-to-surface weapons "capable of supporting deep penetrations or airheads from protected and widely dispersed rear areas; and of delivering accurate fire on distant targets."

Stated purpose of the new Army Regulation, No. 525-30, is to lay down the ground rules for the integration of guided and free missiles into the Army weapons system. But most observers regarded it as another move in the soldiers' campaign to win jurisdiction over the IRBM from the Air Force.

● **Both the Army** and the Air Force are developing 1,500-mile IRBM weapons. Douglas Aircraft Co., Inc., is working on the Thor for the USAF, while the Army's Redstone Arsenal is tackling the Jupiter IRBM. Defense Secretary Charles Wilson has approved the two separate development programs, but he has withheld a decision as to whether both services will be allowed to use the weapon once it is completed.

In discussing the role of artillery and antiaircraft missiles within the Army, the regulation stated: "Such missiles are not merely specialized items of equipment; they have broad and general application to land warfare. All surface-launched missiles which meet Army operational requirements will be developed and integrated into Army forces, as a natural transition from present types of conventional artillery."

The Army described its short-range requirements as including "assault or demolition guided missiles to be used against armor and fortifications," and its medium-range needs as including "missiles to supplement and extend the range or firepower of artillery cannon, to provide close or interdictory fire support for ground combat forces, and to compensate for the expanding dimensions of the battle area."

● **In the crucial area** of long-range surface-to-surface weapons, the Army said it needs "missiles capable of supporting deep penetrations or airheads, from protected and widely dispersed rear areas; and of delivering accurate fire on distant targets which are capable of affecting the execution of the Army's combat mission."

The missile policy regulation said the Army's requirements for surface-to-air missiles "include land-based antiair missiles for defense against high, medium or low altitude aircraft, drones or artillery missiles." It added that such weapons "should also have a surface-to-surface role when feasible" and suggested no limitations on their range.

Missiles Bring Boom To Central Florida

Guided missiles and the forthcoming earth satellite vehicles have brought a boom to Florida's Brevard County and its three towns Cocoa, Cocoa Beach and Rockledge. The area's population has increased from 10,000 to 38,000 in three years and continues to grow.

Air Force estimates 2,000 families will arrive at Patrick AFB during the next 16 months. Currently Air Force has a $4.5-million per month payroll there.

S. GARY BENNETT, Jr.
Real estate up $1 million

Cocoa Mayor S. Gary Bennett, Jr. told MISSILES & ROCKETS the Patrick missile and satellite activity boosted real estate evaluation more than $1 million last year. Real estate people see no reason why this trend will not continue. Cocoa building permits increased more than 100% from 1954 to 1955.

● **But housing** still is the big problem. Furthermore, the water supply to Patrick and the nearby towns is at a critical point. The city of Cocoa is building a $7-million water supply system to meet current and future requirements. A 42-mile long pipeline will transfer water from a well-field west of Cocoa. The system is expected to be completed within the next 16 months

● **In Washington**, a spokesman for the Air Force Family Housing Office said the Patrick housing problem is being studied intensively at the present time. The Air Force plans to start a major housing development on the base for the R&D personnel connected with the Patrick missile and satellite activities.

Big Construction Planned

Major construction programs for missile facilities also are being planned for both the Patrick and Cape Canaveral areas and the Grand Bahamas Missile range to meet the increased requirements of the three services. The Corps of Army Engineers is building the launching site for the Vanguard earth satellite vehicle. This site will include the launching pad with exhaust tunnels, a block-house control station and other facilities.

On the GBI range itself, Pan American World Airways Guided Missile Division continues to expand. On Grand Bahamas, the tracking station employs more than 200 people today, but it is anticipated that more than 1,000 technicians and engineers will be busy there before the first satellite vehicles are ready for launching. In all, the GBI range, which is being expanded to include Ascension Island, requires literally thousands of personnel.

U.S. Sees Possibilities In French Missiles

Agencies of the Department of Defense have been studying French coleopter missiles and have concluded that such missiles may have merit. There is still a question whether they will prove practical in actual operation, which will be difficult to establish without full-size test vehicles.

The French firm Institut Technique Zborowski now has a French government contract to build some full-size test vehicles, and U.S. agencies are watching closely.

Of particular interest is Zborowski's 412-01 *Ogre* photo-reconnaissance vehicle, a long-range missile fitted with an annular wing around the fuselage and a jet powerplant. A 10,000-pound turbine will give the *Ogre* a velocity of close to 600 miles per hour.

Sweden Building Ramjet Missiles

STOCKHOLM—A spokesman for the Swedish Robotvapenbyran, Sweden's guided missile establishment, has confirmed that great emphasis is placed on ramjet missiles in this country.

While Sweden has built *Nike*-type missiles, future surface-to-air missiles will also be ramjet-powered and have greater range. All work on Swedish ramjets is classified. Among leading Swedish missile firms are Svenska Aeroplan Aktiebolaget (SAAB), Svensk Flygmotor A/B, Svenska, Turbinaktiebolaget Ljungstrom (STAL) and Bofors.

SWEDEN'S AIR MATERIEL COMMAND has asked $28 million to procure guided missiles for aircraft and $1,600,000 for continued development of an interceptor missile during 1957-58. Latter item has been in Air Force budgets for several years and is expected to cost about $6 million.

* * *

ACF INDUSTRIES, INC. has set up a Missiles Group to integrate the skills of its Erco, Avion and American Car & Foundry Divisions and apply them to overall weapons systems. Chairman of the new group is Richard F. Wehrling, president of Avion Division.

Super-Propellants Needed, Says Murphree

The most critical job confronting chemists in the rocket-powered guided missile field is the development of super-propellants capable of higher energy release per pound than present fuel-oxidizer combinations, according to Eger V. Murphree, Special Assistant for Guided Missiles to Defense Secretary Charles Wilson.

In a recent talk before the American Chemical Society in Atlantic City, N. J., he declared: "Higher energy production per pound of reactance is of utmost importance from the standpoint of range that can be obtained with missiles."

"Cost of propellants within limits is not nearly so important as the energy that can be obtained per unit weight," he added. He said substantial advances in energy yields will permit corresponding weight reductions and increased mobility in rocket missiles since the bulk of their weight consists of propellant.

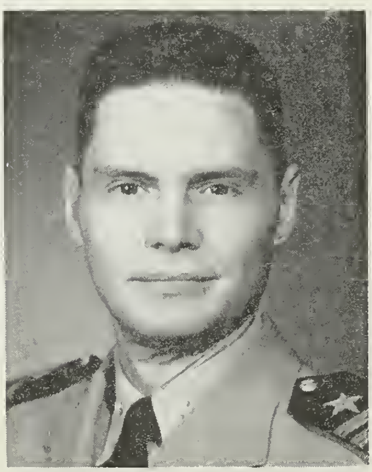
● **In the field** of liquid propellants, Murphree noted that the combination of liquid hydrogen and oxygen, or liquid fluorine and ammonia, would produce "considerably greater energy release" per unit weight than the standard combinations of liquid oxygen or fuming nitric acid and jet fuel, alcohol or other hydrocarbons. At the same time, he pointed out, the more powerful propellant combinations involve considerably more complex handling problems.

On the solid-propellant side of the picture, he said, "There are very real possibilities of getting combinations of oxidizers and organic materials which give higher energy than present propellants," plus the possibility of "new types of energy producing reactions using quite different types of materials."

Solid propellants fall into two broad classes—double-base propellants and composite propellants. The double base variety consists of mixtures of nitrocellulose and nitroglycerin with suitable plasticizers and stabilizers, he said, while the composite type presently consist of some organic material mixed with an oxidizer.

Navy's Truax Guides AF Satellite Work

One of the Navy's most outstanding missile and rocket authorities, Commander Robert C. Truax, currently assigned to the Air Force Western Development Division, is likely to be in the spotlight next month. He's a nominee for the American Rocket Society's presidency. The annual meeting and election of the ARS will be held in New York November 25-30.



COMMANDER ROBERT C. TRUAX

. . . USAF picks the best

Commander Truax was an ensign when he first started to work on liquid rockets in 1941. Since July 1953 he has been assigned to the Bureau of Aeronautics as head of the Ship-Launched Branch, Guided Missiles Division.

Among his contributions to the advancement of rocketry has been his work on liquid rocket-assist for naval flying boats. His missile and rocket experience has been a great asset to the whole missile business and especially to the Navy, although many naval officials may not have been aware of it.

Informed sources believe Commander Truax is guiding WDD's satellite work.

New Problem at Missile Ranges: Overcrowded Telemetering Frequencies

Crowding of the telemetering frequency bands used in missile research and development is posing increasingly severe problems between users at launching sites and between test ranges.

Meeting during the National Telemetering Conference held recently in Los Angeles, a panel of experts from key installations reviewed the needs for better-use coordination and for improved equipment. They also weighed the possibilities of using the newly assigned 2,000-megacycle channel to ease the crowding problem.

W. E. Miller, from Army's White Sands Proving Ground, called attention to the need for improved liaison between contractors using the sites. Day-to-day plans must be made, he said, so that best use could be made of time and frequencies available.

● An example of interference was given by R. S. Reynolds, Sandia Corp. Stressing a need for improved automatic tracking antennas, Reynolds cited a case where an antenna picked up a signal from another missile center 500 miles away and then lost track of the missile it was supposed to track. Better equipment with crystal control was needed, he said, for long-range tracking. This would also aid frequency assignment coordination.

Miller said steps toward improving planning and utilization had been taken at White Sands. A document known as Frequency Utilization Parameters and Criteria, No. 102-56, had been produced by a group at White Sands known as the Interange Instrumentation Group. It is expected the document will aid development of equipment and coordination methods in telemetering work.

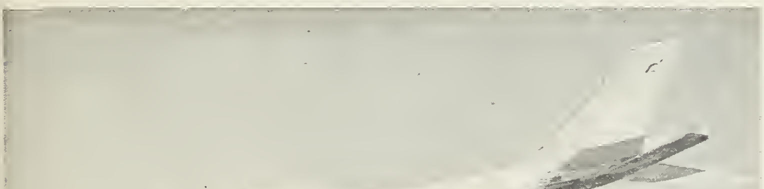
Interference problems should be attacked on three fronts, Miller thinks. These should be: (1) control of frequency usage through careful screening of all requests, (2) better control of equipment frequency stabilization to prevent waste of band space and (3) better control of radiation from closed-loop test facilities where checkouts take place inside of buildings.

● In the serious need for better equipment, Nems-Clarke, Inc. was singled out as having made a significant contribution to frequency-saving by production of its new narrow-band receiver. The receiver permits spacing of standard FM/FM channels only one megacycle apart.

Recently the Department of Defense provided a new telemetering channel in the 2,200-2,300 mc range which was expected to lessen interference problems. However, consensus of the NTC Panel was that the new assignment offered little aid at this time. R. T. Merriam, Naval Ordnance Test Center, China Lake, Calif., said the new frequency was impractical for small missiles. To produce and handle such short wavelengths, microwave "plumbing" such as waveguides are necessary.

● Such hardware takes up much more space in a missile than the 200-megacycle equipment now being used. According to panel chairman George S. Shaw, Radiation, Inc., this amounts to a few hundred cubic inches for the 2,000-megacycle equipment in a missile. He predicts it will be five years before the new band can be utilized for telemetering, except in very large missiles at short ranges not over 100 miles.

Newest 'Demon' Bolsters Navy Missile Power



McDonnell Aircraft's F3H-2M, missile-carrying version of its Demon all-weather fighter, has passed all Navy trial and evaluation programs required for fleet release and joined operating squadrons. New Demon carries four Sperry Sparrow air-to-air missiles plus rapid-firing, high-velocity 20mm cannon. Powerplant is Allison J71 jet. Both F3H-2M and F3H-2N all-weather fighters are slated for production through March 1958.

Nike B Has Longer Range, Greater Speed

Army's *Nike B* missile, now under test and due to be available within two years, will have a longer range than present *Nike's* 25 miles and speed in excess of its 1,500 mph, according to Don Belding, civilian aide to Army Secretary Wilber N. Brucker.

Belding told a recent Los Angeles Town Hall meeting of reports that a *Nike B* with an atomic warhead could destroy a whole fleet of aircraft in one hit if the planes were bunched for attack. He stressed that the new *Nike* can be launched from existing installations with minimum modifications—a factor being questioned by the Air Force in the current *Talos/Nike* dispute.

In disclosing first details of Los Angeles' *Nike* defenses, he noted that each of its 12 batteries has eight officers and 100 enlisted men —two-thirds of them specialists. It cost $20,000 to train each man, $2,-300,000 for a battery, and the payroll for each installation runs $25,-000 monthly.

Research Rocket Zooms To 5,000 MPH in 2 Seconds

Development of a needle-nosed research rocket that can accelerate to speeds approaching 5,000 mph within two seconds has been disclosed by the Air Force Air Research and Development Command. The rocket, called the Hypersonic Test Vehicle (HTV), was evolved by the ARDC and Aerophysics Development Corp. of Santa Barbara, Calif., a new subsidiary of Curtiss-Wright Corp.

Basing figures on the variation of the speed of sound at different altitudes, engineers calculate that the 12-foot long HTV can reach nearly Mach 7 just about two seconds after launching. ARDC revealed that a score of the test rockets have been fired and tested at Holloman Air Development Center, Alamagordo, N.M.

● The HTV is a two-stage solid-propellant rocket vehicle fired from a portable launcher. Seven rockets igniting simultaneously kick off the first stage—five feet long with a diameter of nine inches. When this battery of rockets burns, the first stage drops off and four second-stage rockets boost the remaining section to its top velocity. The second stage is the same length with a six-inch diameter.

The unprecedented acceleration is the rocket's major feature. It develops a velocity rate equal to 100 gravities, at least ten times that of most rockets and missiles.

● Six seconds after the second-stage burnout, a small explosive charge blows off the fins, destroying the rocket's stability and it spins to earth at about 100 mph. Hypersonic data on aerodynamic shapes, aerodynamic heating, rocket stability and air pressure distribution may then be retrieved from the 10-pound nose cone assembly.

The HTV is the first of a group of such high-acceleration rockets, ARDC said. Wright Air Development Center expects to move on to newer research rockets of improved velocity and performance. The first test flight was made in November, 1954, a year or so after work was started in 1953 under a $1,000,000 contract.

Pentagon Planning IRBM and ICBM Launching Sites

Eger V. Murphree's billion dollar responsibility embraces many new and sophisticated missile development concepts. The enormous task that he faced at the time he took on the missile czar job has become even more enormous—not moneywise, but in scope.

First, ICBM development has progressed more rapidly than first anticipated. As a matter of fact, the ICBM program already has reached the stage where one is discussing selection of launching sites. Obviously, hydrogen-warhead ICBMs cannot be launched from air bases or localities near built-up areas and cities. This is one of the new missile system concepts Murphree and the Defense Department must tackle successfully. Planning for IRBM and ICBM launching sites is done now.

Recently, Secretary of the Air Force, Donald A. Quarles, confirmed that work will be pushed to completion on four main air bases in Spain. One of these bases was called a "double base" that might be counted as two. Originally the Air Force counted on nine bases in Spain, but Quarles said it was not quite clear whether all of these would be completed. There has been some talk about the possibility of using overseas bases for launching sites for both IRBMs and ICBMs, but—as can be expected—no official statement has been issued in that respect.

It is not known whether Quarles discussed the missile launching site problem with Spanish authorities during his recent trip to that country, but it is quite probable that he did.

Quarles told a press conference that "there is no question that we will complete those Spanish bases we have started and on which we place great value."

Other U.S. overseas bases feasible for intermediate-range missile operation include those in Morocco.

In all probability, the American bases in Saudi Arabia and Iceland will not be considered for long-range or intermediate-range missile launching. Saudi Arabian King Ibn Saud has granted the United States only temporary permission to continue the USAF operations in that country.

Although the United States Government intends to negotiate with the Saudi Arabian Government for the purpose of obtaining permission to stay on, it is not likely that IRBM launching site negotiations will be attempted. The same applies to Iceland, where the United States position is rather weak.

ARS FALL MEETING:

Nose Cone Re-entry Problem Solved?

Dr. F. Vandrey of the Martin Co.'s aeronautics department stated in a paper on "Upper Bounds and Conservative Estimates for Aerodynamic Heating at Great Altitudes," read before the American Rocket Society's Annual Fall Meeting in Buffalo recently that materials are already available which can stand the intense aerodynamic heating at the nose and leading edges of an artificial satellite.

Using calculations for a missile similar to the *Vanguard* as his example, Dr. Vandrey presented simplified methods for calculating aerodynamic heating at extreme altitudes, pointing out that the 1490°F. skin temperature is still within the short-term stability limits of stainless steel and that the 2740°F. peak nose cone temperature compares with a platinum melting point of 3223°F. Vandrey emphasized that there are a number of other metals, oxides and ceramic materials with still higher melting points.

On the problem of re-entry Vandrey claims "a certain vehicle with low re-entry velocity would not burn up." Which may mean that modification of the true free-fall ballistic nature of the ICBM by equipping it with forward firing rockets to slow its re-entry velocity (now estimated at over 20,-

Furnas Predicts Rocket That Will Circle Moon

A rocket vehicle capable of circumnavigating the moon will probably be the next step after Project Vanguard in the conquest of space, according to Dr. Clifford C. Furnas, Assistant Secretary of Defense for Research and Development.

The Pentagon research chief also predicted that a nuclear powerplant for a rocket "may eventually come into its own," but he said such an engine would be large, heavy and expensive. Such an engine would require only a small amount of fuel, but it would still require a "very substantial" amount of material to eject from the exhaust to develop the necessary drive impulse.

Atomic Oxygen In Atmosphere As Fuel Source?

At the International Astronautical Federation Congress last month Jerome Pressman of U.S. Air Force's Air Research and Development Command, Geophysics Research Directorate at Cambridge Research Center, told of recent experiments which point to possible use of atmospheric atomic oxygen as an energy source to power satelloid vehicles for reasonably long times at altitudes of about 65 miles.

Pressman said that tests at Holloman AFB last March using an *Aerobee* X-1A rocket produced direct evidence of the presence of atomic oxygen at these altitudes as well as its concentrations. Experiment involved release of 18½ pounds of nitric oxide gas to free atmosphere with the *Aerobee* X-1A at an altitude of 66 miles.

• **Most significant result** of the experiment, he pointed out, is the fact that a large amount of energy of the upper atmosphere was released. The energy coming into the earth in the ultraviolet region of the solar spectrum dis-associates molecular oxygen into atomic oxygen, and because of the relatively slow rate of three-body recombination, a reservoir of atomic oxygen exists in the upper atmosphere. These atoms, when they recombine, give off 5.08 electron-volts.

The AF physicist referred to previous research which indicated the number of photons emitted by a sodium cloud of -2 magnitude a value of 6.7×10^{21} photons/second. Assuming the energy contained in the sodium D-line as average for the photons released by the nitric oxide cloud, the total flux of photons emitted per second amount to about 3 hp with an additional 3 hp dissipated in other modes of energy.

The problem, Pressman said, lies in making use of this energy.

Speculating on just how to do this, he indicated the design of a propulsion system suggests itself as a continuous flow type. Use of

a gaseous-type catalyst appears difficult to achieve, he noted, since it would be swept out with the exiting gas.

● **Pressman** discussed two main types of possible systems—one involving a heterogenous type of recombination, the other a homogeneous reaction.

In the former, a direct recombination could occur on the entrance throat of a cylinder, or on a catalytic surface contained within the cylinder. The heated gas would subsequently expand and accelerate outward.

In the homogeneous case, the system would be so designed so as to give a large increase of pressure locally within the cylinder, a feature that might be achieved by a pulse-jet, ramjet, or by shaping the inner walls in the fashion of effusors or diffusors.

The pressure increase, he added, would have to be very large since the partial pressure of atomic oxygen is of the order of a micron and the pressure at which the pertinent reactions of a series of recombinations outlined by Pressman was placed at one millimeter.

● **As an example** of the energy involved, purely for purposes of calculation, he used a hollow cylinder model with an entering throat cross section of 10 square meters and a length of 10 meters. By moving it horizontally at Mach 1 (approximately 300 meters per second) at an altitude of 100 km, with a concentration of 10^{13} atoms of oxygen per cubic centimeter, there is swept out 3 x 10^{22} atoms per second. Assuming 100% efficiency in extracting the energy of recombination from these atoms, this amounts to 15 hp. At Mach 10, it would amount to 150 hp and at Mach 20, 300 hp.

Without calculating drag and lift, he noted that the thrust available at relatively low speeds would be adequate to overcome reasonable estimates of the drag, but not enough to give sufficient lift to maintain a true satellite type of vehicle. He concluded, however, that it would appear adequate as an auxiliary, or possibly prime, power source for maintaining a satelloid vehicle for reasonably long periods in the 65-mile high region.

Satellites Offer Unique Platform to Study Earth's Atmosphere

The lower hemisphere of an earth satellite, bathed in the far-infrared thermal radiation emitted both by the earth and its atmosphere, will provide a unique platform for an astronomical study of the earth in the light of its own emission spectrum, Jean I. F. King of USAF's Cambridge Research Center Geophysics Research Directorate told the IAF Congress in Rome.

No other physical parameter accessible to the satellite contains the wealth of data concerning the thermal state of the atmosphere than that inherent in the far-infrared emission of the earth, King said.

The Air Force physicist pointed out that a far-infrared, thermal-sensing device situated on the satellite would have an obvious use in determining the constituents of the upper atmosphere by a frequency scan of the spectrum.

● **A less obvious**, but potentially fruitful possibility, said King, arises from the variation of the terrestrial emission as the satellite field of view sweeps across the earth's apparent disk. He then proceeded to present the mathematics whereby this variation of emission, (or limb-darkening effect) which is a measure of the departure of the atmosphere from an isothermal state, would produce data on the vertical thermal structure of the atmosphere.

King expressed the opinion that power and weight considerations of the satellite seem to rule out a scanning, gear-driven, infrared spectrometer of conventional design. He noted, however, that a rugged, semi-passive, lightweight filter photometer has recently been developed under Air Force contract by John Strong of Johns Hopkins University for balloon probing of the atmosphere. Its only power requirements are for a chopper blade and an a-c signal amplification.

Such an instrument, King said, could be built with interference filters tuned strategically at 6, 9.6, 11 and 15 microns. The 6-micron filter would receive water vapor radiation, the 9.6 micron the ozone and the 15-micron carbon diozide emission window would see direct to the earth's surface.

King concluded that this would provide a spectral scan of sorts, while a limb-darkening scan would be obtained by a proper distribution of sensing elements on the satellite surface.

Molybdenum May Solve Hi-Temp Problems

Molybdenum, in relatively good supply in the U.S., may prove to be the "answer" metal to ultra-high-temperature flight. Alloys of molybdenum (with less than 1% amounts of calumbium, cobalt and vanadium) are now being researched by both airframe (Convair) and jet engine makers (General Electric).

On 100 and 1,000-hour temperature rupture strengths molybdenum comes out on top of the nickel-cobalt alloys, falling well in the range of the cermets. Unlike the cermets, molybdenum is ductile. In order to overcome the oxidation problem, research is being carried out with a number of coating materials, including those of the platinum group of metals.

The best idea of molybdenum's strength-temperature potential is gained by knowing its melting point (4760°F) and modulus of elasticity (E=50,000,000).

Other efforts now under way to solve the high temperature materials problem includes basic research into ways of making ceramics ductile.

Air Products to Build LOX Generating Plant

A convenient source of liquid oxygen for rocket engine tests will be available for The Martin Co.'s Denver Division when it begins to roll out *Titan* intercontinental ballistic missiles.

Air Products, Inc., Allentown, Pa., announced it will start construction of a $2,810,000 liquid oxygen generating plant as soon as possible on a three-acre, government-owned site adjacent to Martin's new *Titan* plant southwest of Denver. It will go into operation in the first half of next year with a daily capacity of 150 tons of liquid oxygen.

Leonard Pool, Air Products president, said the facility will be sold to the Air Force when it is completed, then leased back to Air Products for operation. Only 20 to 25 skilled engineers will be needed to keep the plant in operation because it features "practically complete" automation, he added.

Rocket Trends

By Erik Bergaust

The American Rocket Society probably is the fastest growing professional society in the United States. Five thousand membership mark may be reached by the end of the year. Nineteen fifty-six has been the society's most "prosperous" year with an average gain of 100 new members per month. Newest section is Philadelphia, mostly made up of General Electric SDPD personnel.

First of its kind? Reaction Motors, Inc., Denville, N. J., is launching a rocket museum. With several hundred items, such as combustion chambers, propellant pump systems, valves, fittings and control system components, the new museum houses many historic gadgets, including early German and American rocket engines.

Hellmuth Walter, famous German rocket engineer, now Research Director for Worthington Pump Corporation in New Jersey, has indicated he is interested in forming a new German rocket company in Kiel. Informed sources seem to think the new Walter rocket company will be registered in his wife's name. A glass factory is currently operated in Mrs. Walter's name, and the rocket company might become its subsidiary.

German missile and rocket comeback is indicated by the fact that BMW (Bayerische Motoren Werke) in Munich has established a rocket propulsion study group. BMW built several liquid rockets during the last war, but none of the wartime rocket engineers are currently employed by BMW.

Future design and construction of atomic-powered rockets and space satellites may be determined by a study of radiation damage to electronic components, according to Admiral Corporation. Company is doing study for Air Force.

Slow-burning solid-propellant research rockets built in Great Britain are designed to fly to 120 miles altitude. Built by R.A.E., the rockets are 25 feet long and 17 inches in diameter. A test program for the new rockets is currently in the works at the Woomera range.

Water-rocket devices for catapulting carrier-based fighters is being studied intensively by the Office of Naval Research. If successfully developed, the water rockets probably will replace the more complex steam catapults now used by the Navy.

A large rocket and space satellite exhibit, to be held in conjunction with the American Rocket Society's semi-annual meeting next spring, is being planned by ARS' National Capital Section.

The German underground factory in the Kohnstein Hills, near Nordhausen (Thuringia), where V-1s and V-2s were made during the war, is reported to be a busy key facility in Russian rocket motor development.

Chrysler Corporation, in its Redstone rocket development, has been praised for outstanding component and system production reliability.

Canada Spent $24 Million On *Velvet Glove* Missile

Total spending in Canada on the recently concluded *Velvet Glove* air-to-air missile project came to just under $24 million, according to Canadian Defense Minister R. O. Campney.

The *Velvet Glove* project was conducted in conjunction with U.S. and British research teams and brought practical experience to some 400 Canadian scientists and specialists in the air-to-air missile field.

As a result, Canadian industry has been geared to produce such weapons and contracts could be awarded to build a Sperry *Sparrow* type air-to-air missile.

* * *

THE AIR MATERIEL COMMAND at Dayton has announced the following contracts: Avco Manufacturing Co., Cincinnati, O., $25,150,558, fire control systems, spare parts, components and data; Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., $600,000, for facilities in support of guided missile programs.

C-W New Factor in Missiles Field

Outright purchase of Aerophysics Development Corp., formerly a wholly-owned Studebaker-Packard subsidiary, has installed Curtiss-Wright Corp. as a first-line missile-builder.

Only days after the ADC purchase, C-W won a $16,565,000 contract from the Army for the *Dart* anti-tank missile. It will be built by Utica-Bend Corp., another C-W subsidiary formed as an outgrowth of the S-P deal, in a plant at Utica, Mich.

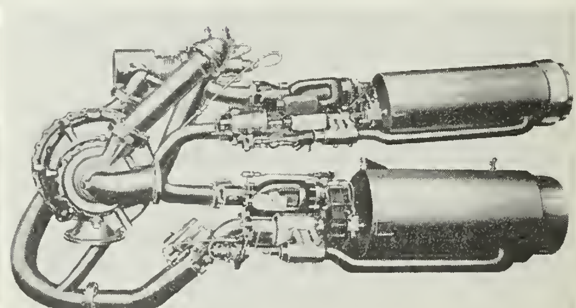
The *Dart* was developed at Aerophysics before the Santa Barbara, Calif. firm joined Studebaker-Packard. Powered by a solid-propellant rocket, the new Army missile is based on an earlier development by France's SNCA du Nord. It is wire-guided and has a range of 1,000 to 2,000 yards.

● **According to** some industry reports, the *Dart* is the "last word" in missile design for simplicity, low unit cost and producibility. For example, it is said to employ a non-electrical gyro system to obviate the need for complex electronics devices and power supplies in its stabilization.

As part of the Studebaker-Packard deal, Curtiss-Wright has taken a 12-year lease on S-P plants at Utica, Mich. and South Bend, Ind. and will pay for all work in process at a cost of $25 million. It has also arranged to supply S-P with $15 million more, by underwriting an extension of its credit.

Other elements of the transaction give C-W a three-year contract to provide the auto firm with management advice, as well as an option to buy 5,000,000 shares of S-P stock. Latter is subject to approval of Studebaker-Packard stockholders and their agreement to reduce par value of the stock from $10 to $1 a share.

Last phase of the deal involves an agreement with West German firm of Daimler-Benz A.G. which will give S-P rights to important German developments in the diesel and gasoline engine field.



Curtiss-Wright's XLR-25-CW-1, liquid-propellant rocket engine is rated at 15,000 lbs. thrust, uses two thrust chambers (top). Bottom photo shows engine operating on test stand.

Washington Spotlight

By Henry T. Simmons

Pentagon insiders regard the *Talos* surface-to-air missile as a "minimum" area defense weapon and take a skeptical view of the Air Force's argument that it will be valuable preparation for the *Bomarc.* Real reason the airmen want it is to head off Army missile ambitions—specifically, the 50-mile *Nike B.*

A committee headed by Pentagon Missile Czar Eger V. Murphree is looking into the technical merits of the competing *Talos* and *Nike B* systems, but no decision has yet been reached. Comments one official: "The country would be darned well off to have both." Nevertheless, only one system is likely to be adopted, and *Nike B* looks like the better bet, provided it can be introduced without tremendous modifications to existing *Nike* batteries.

Navy's air-to-air *Sidewinder* missile is now operational on carriers in the Mediterranean and Far East. Formal announcement is expected shortly. It is believed to be the first heat-seeker bird to reach operational status.

Sidewinder's homing system is sensitive enough to lock on a smoldering cigarette at 100 yards. Navy wags claim it unerringly picks the hottest cylinder of a piston engine as its target. As an economy measure, drones dangle incandescent torches during firing tests. These are regularly lopped off by the Philco-produced *Sidewinders* so the drones may be used another day.

North American twin-ramjet *Navaho* probably will be the first intercontinental missile to be produced in quantity for the military arsenal. Northrop *Snark,* although ready for volume production now, looks like it will be by-passed in favor of the higher-performance NAA weapon. Latter still has many months of development work ahead of it.

Diamondback is a study project for an air-to-air missile. As the name would indicate, it is a potential successor to another member of the rattlesnake family—*Sidewinder.*

Navy *Vanguard* satellite scientists figure the first two seconds of the launching operation will be at least as critical as any other phase; the gimballed motor of the first stage cannot be swivelled more than four degrees in the early part of the flight because of the sloshing liquid propellants. Thus a vagrant wind could bring disaster in the initial instant of launching.

Air Force construction plans for intercontinental missile launching facilities provide for such tremendous dispersion that no more than one-third of any given battery's firepower would be lost in the event of a direct hit by an enemy missile with an H-Bomb warhead.

The extent of the missile's impact on USAF weaponry is revealed by these planning estimates: Eventually 90% of the missions of the Air Defense Command, 50% of the Strategic Air Command's missions and 40% of Tactical Air Command's targets will be handled by the canny birds.

SPECIAL REPORT:

RUSSIAN ATOMIC ROCKETS UNDERWAY

Soviets Join International Astronautical Federation, Will Assist in Satellite Program

By Erik Bergaust

ROME—At least two atomic rocket research projects are believed to be in the works in the United States, but even so the Russians may be ahead of us. This was revealed here during the 7th Congress of the International Astronautical Federation.

Russia's interest in satellite science and astronautics has, furthermore, been accentuated by the fact that the *Astronautics Commission* of the U.S.S.R. Academy of Science applied for and was admitted to full membership in the federation at this Congress.

Just how interested the Russians are in rocket and satellite activities during the International Geophysical Year was expressed in a statement by Professor I. P. Bardin, Russian International Geophysical Year Committee Chairman.

In his statement, given to Dr. M. Nicolet, Secretary General of the Comité Special de L'Année Internationale Geophysique, Prof. Bardin made these points:

1) In addition to the U.S.S.R. program already presented to the Barcelona International Geophysical Year Meeting, Russia's rocket-satellite program will be presented at a later time.

2) The U.S.S.R. is interested in launching a satellite by means of which measurements of atmospheric pressure and temperature, as well as observations of cosmic rays, micrometeorites, the geomagnetic field and solar radiation will be conducted. The preparations for launching the satellite are presently being made.

3) Meteorological observations at high altitudes will be conducted by means of rockets.

4) Since the participation of the U.S.S.R. in the IGY rocket-satellite observations was decided quite recently, the detailed program for these investigations has not yet been elaborated. This program will be presented as soon as possible to the Secretary General of the CSAGI.

Russian delegate to the IAF Congress, Dr. Leonid Sedov, Moscow University professor, declined to comment when MISSILES & ROCKETS asked him whether the Soviets would launch more than one satellite.

Dr. Sedov did confirm, however, that Russian atomic rocket research is progressing at various nuclear research centers throughout the Soviet Union.

● A short time ago Russian research engineer G. Nesterenko said that "engines performing on nuclear fuel are of great importance in our contemporary aviation and rocket engineering. Powerful and highly efficient atomic engines will enable us to build rockets that will overcome the gravitational pull of the earth."

Rocket engines with atomic reactors mounted directly in the combustion chambers have been discussed openly in Russia. Active U235 and U238 reactor mass and a graphite neutron inhibitor have been suggested. Liquid hydrogen will flow through the porous mass, cool the reactor and at the same time acquire tremendous energy. Nesterenko has calculated the exhaust velocity to be in the neighborhood of 22,000 feet per second.

Heat, Weight Problems

Heat in this type rocket reactor is controlled by movable controlling shafts prepared from porous cadmium, acting like "fire extinguishers" in regard to the chain reaction. Liquid hydrogen cools the shafts.

"The problem of heat transfer is considerably lessened by the use of porous materials in the reactor," Nesterenko said. "Such ma-

Pope Blesses Man's Efforts to Conquer Space

Pope Pius XII has given his blessing and benediction to mankind's efforts to conquer space.

"God has no intention of setting a limit to the efforts of man to conquer space," he told members of the 7th International Astronautical Federation Congress in Rome.

The 400 delegates were received by the spiritual leader of the Roman Catholic Church at his Castel Gandolfo summer residence.

"The more we explore into outer space, the nearer we come to the great idea of one family under the mother-father God," the 80-year-old Pontiff said.

"This astronautics congress has become one of great importance at this time of man's exploration of outer space. It should concern all humanity. Man has to make the effort to put himself in new orientation with God and His Universe," the Pope concluded.

Newly elected vice president of the IAF, Moscow professor Leonid Sedov, leaned forward attentively and nodded his head in agreement when other delegates translated the Pope's address from French into German for his benefit.

terials offer a large surface area for the liquid hydrogen."

● **What the Russians term** a "fluido-reactive rocket," using liquid hydrogen, must be very heavy, they admit. But ways to decrease the weight of the reactor are being sought. Nesterenko thinks the "critical dimension" can be decreased by the use of enriched uranium that contains a large percentage U235, by installing special reflectors of neutrons and by substituting the graphite with an improved inhibitor for the rapidly moving electrons, etc.

"Such measures should decrease the weight of an atomic rocket at a ratio of 10:1. Thus the construction of an atomic rocket vehicle of from 100 to 200 tons total weight is possible today," he asserted. Russian interest in atomic rocket engines is confirmed by another official who says that the biological problems, i. e., radiation hazards for passengers in atomic aircraft —whether they are propelled by jets or rockets—are under study.

When the subject of Russian atomic rocket research was discussed with Dr. Leonid Sedov during the IAF Congress, he could not confirm whether the trend suggested by Nesterenko was indicative of what type reactors and materials are being considered in Russia.

"I am not a propulsion man," he said. "I am an astrophysicist. However, I can confirm that we are very much interested in 'these things' and that they are being worked on."

● **Dr. Sedov,** who preferred to converse in German, made a considerable impression on IAF members at last year's international congress in Copenhagen, where he held a press conference at the Soviet consulate. At that time he announced that Russia was building "a satellite that might be launched sooner than the one announced by President Eisenhower."

Because of the questionable publicity Dr. Sedov was given after last year's meeting with the press, he refused to hold another press conference this year.

One of the American scientists, who carried in his briefcase a number of small transistorized telemeter units and cosmic-ray counter components of the types suitable for small satellites, was asked by Dr. Sedov if he would be willing to sell them. Said the American scientist: "I will send them to you when you send me some samples of the components you're putting into your satellite."

Dr. Sedov, who has a fine sense of humor and is very popular among American and German scientists, expressed his gratitude when the delegates unanimously approved the Russian application for membership in the IAF.

"We look forward to working with the societies from other countries," he said.

Biggest IAF Congress

Retiring IAF president Frederick C. Durant, III of Arthur D. Little, Inc. told MISSILES & ROCKETS that this congress had been the "biggest and most important" since the world organization was founded in 1950. More than 60 Americans attended, including representatives of the Air Research & Development Command, the Naval Research Laboratory, the Office of Naval Research, the Cambridge Research Center and other official bodies. Some of the eminent American scientists included Dr. Theodore von Karman, Dr. Joseph Kaplan, Krafft A. Ehricke, Dr. Homer Newell, Dr. Fred L. Whipple, Dr. Fred Singer, and others.

● **Numerous scientific papers** were presented. More than a dozen pertained to small, artificial satellites, four dealt with lunar rockets and a variety of papers discussed rocket technology and astronautical problems in general.

The Congress was held at the beautiful Palazzo dei Congressi. A record attendance of 450 delegates from 22 countries convened for a full week from Sept. 17-22. The members were welcomed by Rome's Mayor and later in the week were received by Pope Pius XII at his summer residence, Castel Gandolfo.

Although the U.S. earth satellite program for the IGY and the Air Force camera-equipped reconnaissance satellite have been the only two space flight projects discussed officially in the United States so far, MISSILES & ROCKETS learned reliably that there are actually several space flight

IAF Congress Personalities

SEDOV and FREDERICK DURANT
New East-West Vice Presidents.

KRAFFT A. EHRICKE
Solar power for travel beyond the moon.

DR. JOSEPH KAPLAN
Wanted: observers all over the world.

SAENGER & SAENGER-BREDT
Predicted: bright future for photons.

Special Report

projects under way. Since most of these are conducted by military organizations, and since much of the vehicle technology involves missile techniques, none of them have been revealed.

● Several of the most important American universities and several scientific organizations are said to be involved in different types of space flight studies embracing larger satellites, lunar rockets and vehicles designed to circumnavigate the moon.

Within three or four years we are likely to go beyond this thing of sending a small, un-controlled shell to the moon, one scientist said. "If you want to go for a trip in the country and you can't afford a Cadillac, you'll use a scooter. But if you have a Cadillac you'll use that one—and that's pretty much the situation today. Our rocket industry has the Cadillac—so why bother with the small stuff?"

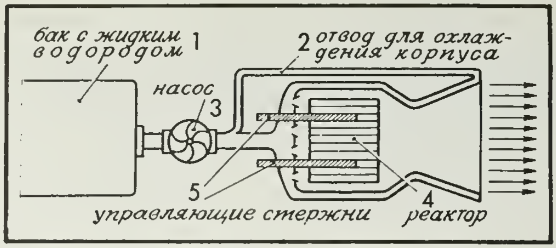
"I feel convinced that we will launch numerous larger satellites into all kinds of orbits within the next decade," Durant said in his opening speech.

● **The peaceful aims** and objects of the IAF and of astronautics as a science were emphasized throughout the congress. A Cambridge Research Center Aerobee sounding rocket at display attracted much attention.

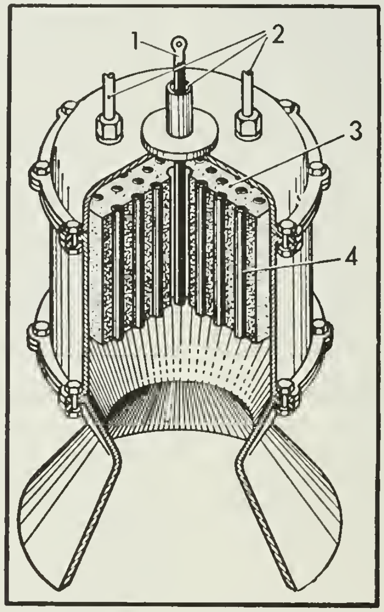
"The slogan of this congress could well have been 'Rockets for Peace" and research rockets such as the Aerobee and Vanguard prove that this is possible," Durant said. The announcement that the United States and Canada will conduct jointly a multi-million dollar program for rocket exploration of the atmosphere in the Arctic region and Russia's forthcoming meteorological program, using rockets, were among the favorite discussion topics of the delegates.

Great Interest in Vanguard

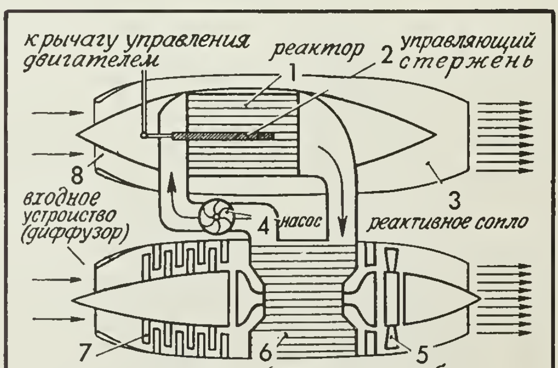
President Eisenhower's announcement July 29, 1955, that the United States would participate in the IGY with an artificial satellite program, coincided with the opening of last year's IAF congress in Copenhagen. This year technical



Schematic view of Russian "fluid reactive" engine. 1. Tank for hydrogen. 2. Regenerative cooling pipeline for hydrogen. 3. Pump. 4. Reactor. 5. Controlling rods.



Schematic view of Russian atomic rocket. 1. Control shaft (rod). 2. Pipelines for liquid hydrogen. 3. Graphite. 4. Rods of U235.



Schematic view of nuclear-fuel turbo-reactive engine with ramjet. 1. Reactor. 2. Controlling rod. 3. Exhaust nozzle. 4. Pump. 5. Turbine. 6. Heat exchanger. 7. Compressor. 8. Air intake and diffuser.

papers pertaining to the *Vanguard* were presented. Interest of the European press in the *Vanguard* program was high. Italian newspapers carried as much as a full page of reports and pictures on the subject.

N. E. Felt, Jr. of Martin, Baltimore, presented a paper on the *Vanguard* launching vehicle and revealed the basic construction of the three-stage carrier rocket. The true significance of the project is that we have accepted a challenge to create something never before seen by man, he said. "This device is something to be used for the advancement of mankind by extending our knowledge of our environment; we have taken the first step in the exploration of the universe," he said.

● **Dr. Whipple,** in charge of the visual observation of the American IGY satellite, told MISSILES & ROCKETS that the Smithsonian Astrophysical Observatory will activate some of the observer groups throughout the U.S. in November and December. These groups will start "training" and be checked out for timing and coordination. The experiences gathered will be offered other groups all over the world. The so-called "Moonwatch" program now has reached the stage at which such a nationwide practice session is both desirable and necessary, Dr. Whipple stated.

"When we activate our observer groups late this fall, this will be a full-scale rehearsal, including a communications tryout, for the forthcoming IGY satellite tracking," he said.

The Federation passed a resolution to encourage its member societies to offer assistance to the IGY chairmen in their respective countries for visual observation and tracking of the IGY satellites.

British atom-physicist Leslie Shepherd of Harvell University was elected new president of the IAF. Russian delegate Dr. Sedov was elected vice president. Four other vice presidents elected were: Durant, Gen. Paul Bergeron, Julio Marial and Prof. Teofillo M. Tabanera. Next year's congress will be held in Barcelona October 7-12. The Netherlands will be host to the 1958 congress.

NUCLEAR ROCKET RACE ON

• Atomic Energy Commission Conducts Basic Research —NACA Believed to Be Working On Second Project

In an effort to attract more trained personnel to the project, the Atomic Energy Commission has announced that two of its laboratories are engaged in nuclear rocket development projects. Work has been going on for the last year at the Livermore Branch of the University of California's Radiation Laboratory in the San Francisco Bay area, and the Los Alamos Scientific Laboratory in New Mexico, operated by UCLA.

The Los Alamos phase of the work is being conducted by the "N Division" under the direction of Dr. Ramer Schreiber. AEC officials declined to discuss either possible advantages or methods of achieving nuclear rocket propulsion. However, an obvious advantage is low fuel weight and virtually unlimited thrusts.

● **Other disadvantages** that must be overcome include development of materials or possible electrical-field methods of withstanding the tremendous heats of reaction—even greater than the sun-surface temperatures encountered in the ICBM long range missile; the heavy weight of shielding necessary to protect personnel (if the vehicle's to be manned) and instrumentation from high-intensity radiation; and development of a means of controlling the reaction.

Fuel-metering can probably best be achieved by the use of fissionable materials in solution, such as that used in homogeneous reactors. This could be sprayed into the reaction chamber from the perimeter to gather in sufficient concentration at the center to produce a "boil-up" reaction.

Another possibility is a solid hot reactor feeding into the firing chamber in the same way a self-consuming electrode feeds into an electric furnace.

Another interesting problem will be posed in flight-testing such a vehicle. Wherever it might crash, it would be troublesome.

● **Also in the field** of nuclear propulsion, the AEC in its latest semi-annual report discusses the progress of work towards controlled fusion and presents some possibilities for the far future.

It says: ". . . it is conceivable that a controlled thermonuclear reactor (burning a fuel of Helium-3, for example) might eventually be developed which would produce no neutrons at all, and for which no neutron-shielding would be required."

Such an engine would not rely on mass airflow for its propulsive medium (as will present atomic aircraft engines now being developed), but would utilize the direct energy of reaction as do today's rocket engines. Thus, it would not be limited to atmospheric operation.

And from the point of view of safety, the AEC report says it would be "extremely safe . . . fuel supply itself would be stored completely outside the machine chamber and would be completely incapable of participating in the reaction without first being introduced to the reactor and heated . . . no fission products to escape in case of an accident."

Basic obstacle to development of such an engine is the high temperature (hundreds of millions of degrees) of reaction, but AEC feels an insulating effect may be achieved through the use of electrical and/or magnetic fields. The fusion engine would be started by means of local particle excitement rather than relying on an A-bomb trigger. Power rate could be controlled by metering gas admitted to the reaction chamber.

Propulsion Notes

By Alfred J. Zaehringer

The NRL AEROBEE-HI rocket that got up to 163 miles June 29 was the result of considerable re-design after two successive failures. Blame was placed on motor—probably the injection system. Meanwhile NRL denies that the new rocket is a prototype of Stage 2 of VANGUARD satellite vehicle.

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Two plants at Niagara Falls, N. Y. are producing new propellants (for rocket and/or for "chemical fuel" air breathing jet engines). Stauffer Chemical is upping the production of boron trichloride by a factor of ten. Nearby Olin-Mathieson is producing alkyl boranes ("Zip") at a $36 million USAF plant. The OM plant was recently battered by an explosion of major proportions. (See "Industry Spotlight")

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LOX-fueled REDSTONE makes extensive use of aluminum alloys. Hints are that REDSTONE'S kissing cousin JUPITER will also be LOX-fueled but may use lighter-weight alloys such as magnesium. First firings of an entire JUPITER IRBM (FBM) and ATLAS ICBM are near. Nevertheless, there has been considerable talk that the Chrysler IRBM may also go through a parallel solid-propellant version.

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MARS is the Missile and Rocket Section research group of the University of Detroit's Research Institute of Science and Engineering. Both solid and liquid propellants will receive attention. Headed by Dr. Donald J. Kenney of the U. of D. Chemistry Dept., MARS will utilize production and test facilities of American Rocket Co. Under the joint industry-university program engineering talent will be shared.

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Capabilities of heretofore classified solid-propellant units have been revealed by Coleman Engineering, operators of the USAF SMART track at Hurricane Mesa, Utah. HVAR has been used for low-speed runs (acceleration and sustaining) and for retro-firing (braking). Burning time is 0.86 sec. New solid-propellant booster unveiled is the 224B-1 with a burning time of 4.6 sec. T-50 booster also used for the zero-length launching of MATADOR has a burning time of 2.5 sec. and is used in combination with the 224B-1. LOKI with a burning time of 0.8 sec. has also been used as a sustainer.

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Three solid propellant SMART sleds have been built. The MM-1 mounts three HVARs for acceleration, three 5KS-4500s for acceleration, and six HVARs for retro-firing braking. The 5KS sled carries twelve 5KS rockets and uses water braking. The 224B-1 sled is designed for Mach 1.7 runs but Mach 2 runs are being planned with a T-50 pre-boost sled, a 224B-1 booster sled and a forward test sled. Solid-fuel rockets give flexibility in thrust and burning time by using the various combinations. However, Coleman claims liquid-fuel rockets permit greater operational economy and variability. No details have been released about the liquid units.

BRITISH LEAD IN LIQUID RATO AIRCRAFT

FARNBOROUGH—British rocket engine progress was demonstrated here during the Society of British Aircraft Constructors' show last month. MISSILES & ROCKETS correspondent was particularly impressed by the colorful and dramatic rocket-assisted takeoff of the Vickers *Valiant* giant bomber. The British are undoubtedly ahead of the United States in the field of liquid-rocket-assist aircraft.

The mighty *Valiant,* forced to demonstrate its performance under poor weather conditions, with rain and low-hanging storm clouds, lumbered across the field to the end of the runway. The four jets reached their penultimate scream, the pilot released the brakes, and in a matter of seconds the big bird began its climb into the dark clouds.

Then came the rockets with their spine-chilling roar. Tilting upward at an incredible angle, the huge bomber zoomed aloft, the two auxiliary rockets mounted underneath each wing sputtering characteristic shock diamonds.

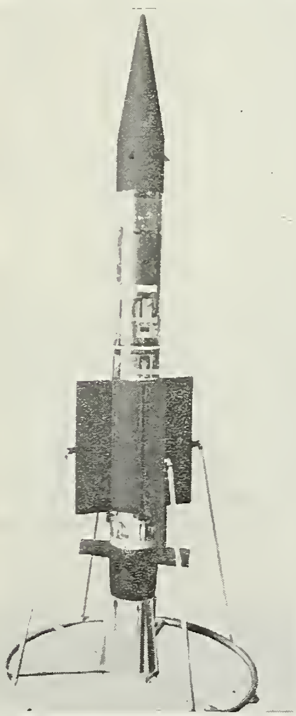
While the *Valiant* Super *Sprite* rocket engine only yields 4,200 pounds of thrust, Armstrong Siddeley has produced the *Screamer,* with a thrust rating of 9,500 pounds; this and similar engines are scheduled to be produced for several British aircraft, both fighters and bombers.

The following is an alphabetic run-down of the main missile exhibits at the SBAC Farnborough show.

● **Avro** introduced its Weapons Research Division with a simulator, a computor and a display of shock-resistant, resin-potted, transistorized circuits—a DC to DC converter stepping up 12 volts to 150 volts with a capacity of 15/20 watts at 75% efficiency: a half-cycle magnetic amplifier with a gain of 2,000: a snap-action magnetic amplifier shown operating a lamp on 0.1 volt, claimed as a gain of ten million.

● **Bristol** showed its production missile ramjet, the *Thor,* and its compact hydraulic turbo-power pack and a turbine fuel pump. Bristol revealed two coaster vehicles with cruciform low aspect ratio wings and cruciform tail blades at 45°, used for aerodynamic data gathering during a 10-sec. deceleration from an initial rocket-boosted 1,360 mph. Launching takes 2 secs., with a peak of 35g's. Bristol's extensive work on welded high-alloy steel rocket cases and pressure vessels was extensively displayed.

● **English Electric** was security-bound to a model of last year's missile, plus a very similar parachute-recoverable coaster used for training on a normal artillery range. A triple-rocket tail-booster gives an initial speed of 1,360 mph. The company's Mark VI temperature-controlled gyro achieves the remarkably low drift rate of 1°/hour by virtue of being immersed in a viscous fluid to resist shock and maneuvering loads. A compact exhaust-operated power pack consists of two cylindrical accumulators recirculating fluid, one to the other, through a sealed turbine under pressure from internal gas bags. Both low and high pressure filters of sintered bronze ensure continuous functioning.



Declassified photo of one of early types of control test vehicle built by Bristol Aircraft Ltd. Maximum velocity exceeds 2,000 ft./sec. Peak acceleration is 35 g's. Triplex tandem boost burning time is two seconds.

● **Fairey** had its Fireflash, the RAF's first production (training) missile on the Vickers Supermarine Swift F7, the Hunter F4 and on an assembly/loading trolley and on a "yes/no" pre-launching test table. The Fireflash is a beam-riding coaster launched from an underwing position by twin cordite boosters which jettison automatically at burnout.

● **Ferranti's** connection with the Bristol missile program was emphasized by the presence of printed wiring and transistorized circuits on the latter's stand.

● **Napier** showed its production 2,000-lbs.-plus production missile rocket motors, the NRE 11 and NRE 17, the ramjet combustion test vehicle NRJ 1 and the fuel supply pack operated by ram pressure. This latter inducts air from two one-inch-diameter pitot heads, then diffuses it into a turbo-pump. Altitude and air speed regulation of the fuel supply are provided from dynamic/static pressure measurement.

● **Royal Aircraft Establishment** (Wescott)had the last word with its 50,000-lbs. thrust rocket-chamber/nozzle. This is a spherical chamber with divergent nozzle built from 32 identical individual "leaves" of argon-arc welded 18/8 stainless steel. Each "leaf" is of two skins, hydraulically inflated to provide cooling passages and molded to form. Kerosene at 800 lbs./sq. is fed through the passages to give regenerative cooling before spraying into the chamber to mix with the LOX for combustion. Instead of entering through nozzles, both propellants are injected through perforations in the inner skin of the chamber. Combustion pressure is 500 lbs./sq. in.

TEAMWORK:

Key To Success in Guided Missiles

By Dr. Wernher von Braun

Guided missile development is a young art. Certainly this makes it a rather fascinating art. Here is a fertile operating ground for creative minds and the younger generation is well aware of this. I receive many letters from young people asking advice on how to become a guided missile expert. I usually advise these inquirers that there are no such animals, for a successful guided missile system is the result of human teamwork rather than a specific idea or achievement on behalf of an individual expert.

The missile field, extending as it does into technical areas as far apart as fuel chemistry and ultra-high frequency radio, stress analysis and supersonic aerodynamics, materials research and gyroscopes, pure mathematics and shop management, cannot possibly be encompassed by a single brain. As in baseball, good players are needed but it is the quality of the teamwork among these players that de-

"You put a lot of work into it and at the end someone pushes a button and the thing is irretrievably gone

cides whether they are big league or bush league.

As long as a new guided missile project is still earthbound—that is, in the stages of planning, design, manufacture, laboratory work and ground testing—we are relatively safe from serious setbacks. The acid test comes when we begin the flight testing. There are a number of reasons for this.

Intricate Relationships

● **In the first** place, there is an intricate functional cross-relationship between construction elements emerging from those vastly different scientific and engineering fields which make up the art of building guided missiles. A "bug" in a guided missile does not care how the development agency has been organized, and who was responsible for what.

Take for example: There is a vibration in a missile caused by the rocket engine. The vibration is picked up by a sensing element belonging to the guidance system, is amplified by the control circuits, and causes a hunting of the control organs which, in turn, breaks up the structure of the missile in mid-flight. Whose fault was it? Who is to be blamed? What is to be done about the bug? Only men working together as a team and familiar with the scientific and the hardware angles of the missile, can successfully remedy such a situation.

The Author . . .

is recognized as the world's greatest authority on ballistic missiles. MISSILES & ROCKETS *is honored to publish this article, which is the first he has written on human relations and missile developments. Dr. von Braun is a member of* MISSILES & ROCKETS' *Editorial Board. He is presently Director of Development Operations Division, U. S. Army Ballistics Missiles Agency, Huntsville, Ala.*

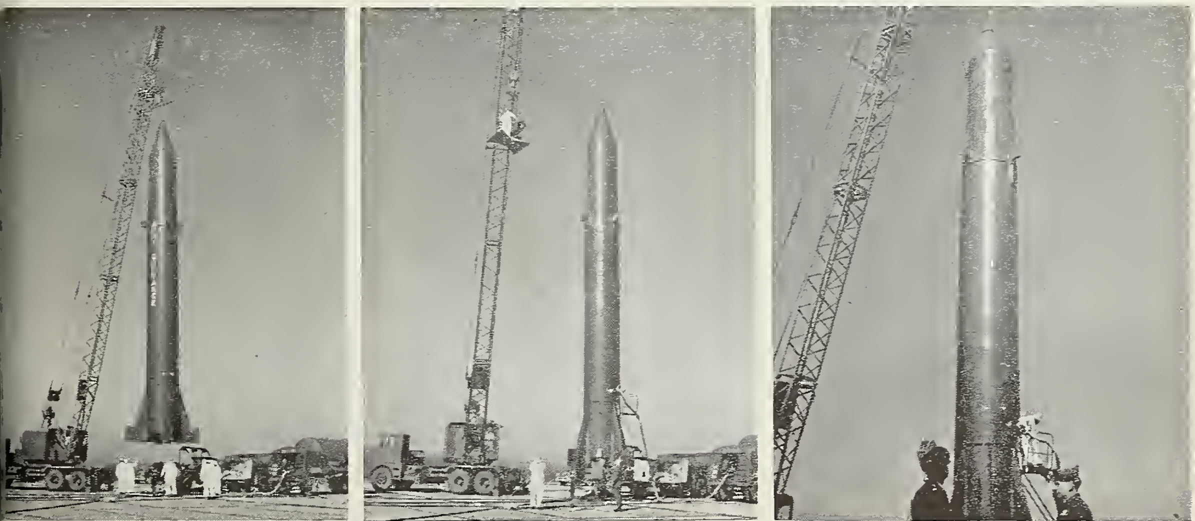
But before one can even sit down and analyze, one first must have the facts of what actually happened. The missile may have broken up above the clouds and the debris may have fallen irretrievably into the ocean. Nor is there a pilot to return to the base to report about discrepancies he may have observed prior to the break-up.

To observe the behavior of missiles in flight, we depend entirely on telemetry and tracking, both of which involve complicated electronic techniques. Telemetry radios to the ground pieces of information collected by a variety of eyes and ears, called "endorgans," which we have previously endeavored to place in strategic or critical locations throughout the missile. Alas, it is quite difficult to know in advance what will turn out to be a "critical location."

● **Management** of a successful missile program depends to a large degree on its capability of correctly and rapidly analyzing causes of malfunctions observed in test flights. It is easy to see that this task is the more difficult the more geographically and organizationally decentralized the project is handled. For more decentralization means more room for misunderstandings, less opportunity for people to grow together as a team, and less opportunity to familiarize a sufficient number of people intimately with the entire missile system, every part of which is a potential source of trouble.

It is an undisputed fact that a substantial number of test missiles must be fired before a new type missile emerges from the research and development phase. Thus, as we find it necessary today to modify the design as a result of yesterday's firing, we have to incorporate this modification into a number of missiles which, in various stages of completion, are being readied in our shops for future firings.

The period of time required for this process of analyzing flight tests, designing, building and testing the modified parts, and finally incorporating the modifications into missiles in the assembly shop is the best yardstick for any suc-



anywhere between 50 and 100 missiles for the development and another 50 to 100 for field-testing."

cessful, speedy missile system development.

Facts and Theory

All this, of course, means that production of guided missiles must begin before we know our own end product. Most production men will tell you that this is just plain nonsense and that every branch of industry will confirm that orderly documentation, meaning a complete set of drawings and specifications, is an absolute must for any successful production.

All we can say is that such production men had better learn a few things or stay out of the guided missile business. Unlike a tank, a gun or an airplane, a guided missile is a one-shot affair. You put a lot of work into it and at the end someone pushes a button and the thing is irretrievably gone. You need anywhere between 50 and 100 missiles for the development and another 50 to 100 for the field testing phase of a new guided missile system. So you have to provide not just a pilot line but a good-sized production before the design may be reasonably frozen.

Experience shows that a typical large guided missile system involves approximately 60 to 80 thousand engineering change orders on the missile alone between the first successful flight and the release as an operational weapon system. It may be a good guess to assume a similar figure for the ancillary ground support equipment.

If there were plenty of time, all this still wouldn't be too bad. We could move along cautiously and speed up this intricate process of analyzing, modifying and producing as our organization learns to function as a team.

The trouble is that we never have this time. Unless we can get a new missile system into the hands of the troops inside of five years after the development was started, the system is likely to be obsolete before it is ready for operational use. There is a saying in the Strategic Air Command to the effect that SAC has no up-to-date airplanes, that all of SAC's airplanes are either experimental or obsolete. The same can be said about guided missiles.

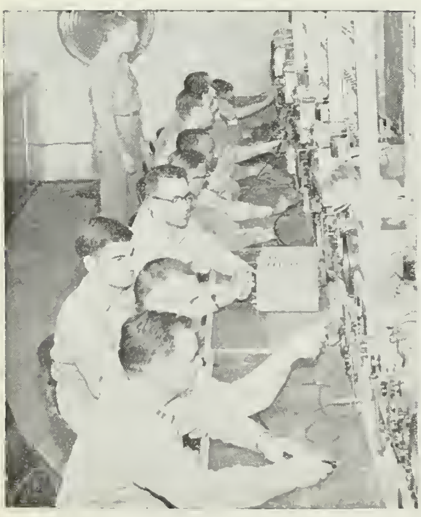
And yet, even if we are ready to accept the fact that only obsolete guided missile systems will ever attain operational readiness, we must still bear in mind that development costs for major guided missile projects amount to several hundreds of millions of dollars per system. To justify such expenses the weapons systems must have at least five to ten useful years.

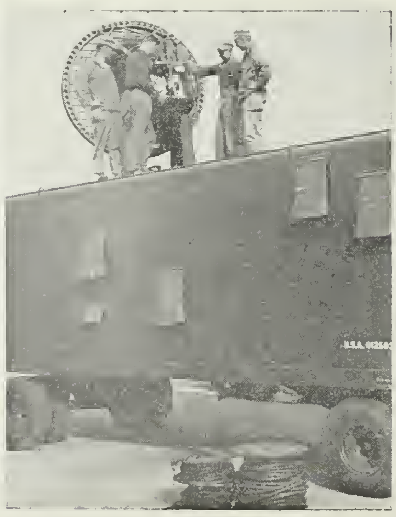
Crash Program Needed

● The conclusion is obvious. We simply cannot afford to develop a major new guided missile system on any other but a crash basis—nor may we assume that a potential enemy could not afford it. It is clear that the need for "crash" further greatly enhances the difficulties for the developing agency. Any development organization artificially pieced together by management decree does not have a Chinaman's chance to succeed in the race for superior guided missile systems. The job can only be done by a smoothly working team. What then makes a good team tick?

Any good team, no matter whether baseball or guided missile, is distinguished by certain qualities that are hard to appraise in sober scientific terms. In a good team there is a sense of belonging, of pride, of group achievement. There is an element of spontaneity in it. A good team must grow slowly and organically like a tree or a flower. All that management can provide to make a good team grow and blossom is a healthy working climate. Like a gardener, management can see to it that the flower has good soil, sunshine, water and fertilizer. Nature must do the rest.

Building a team is a slow process and there is trouble when one tries to speed it up too much. Just as one can burn a flower with too much fertilizer, one can badly hurt the growth of a healthy team by not providing sufficient time for new





TEAMWORK • • • key to missile system success—in the control room, on the tracking van, for acquisitio

team members to get acquainted with each other. Whether they are scientists, engineers or mechanics, they must be given an opportunity to learn to appreciate the capabilities and accomplishments of their fellow team members. In guided missile development this is particularly important because there simply cannot be an argument as to what professional group is more important.

Once a group of scientists and engineers has learned to work together as a team they will laugh at such debates because they realize that they are dependent upon each other.

The picture of the gardener may appear a bit lyrical at a time when for sheer national survival we are faced with an urgent need for long-range ballistic missiles. And yet at this point I am tempted to quote a distinguished New England scientist who, when I asked him how long he thought he would need to complete a certain development program, replied, "Two years. But if you rush me it may take three."

The following factors are in my mind most essential and, in fact, indispensable to a successful guided missile team:

● **Maximum delegation** of authority. In a field as many-faceted as guided missiles, many, far too many, experts from various fields are needed. Men to whom leading position in a guided missile program have been entrusted should be modest enough to realize that they themselves depend on the successful and smooth functioning of the team as a whole just as much as any teammate in a lower echelon. It is impossible to run a successful guided missile program in a high-handed fashion.

● **An efficient and continuous** system of communications from top to bottom and from bottom to top. Here again the responsible team leaders must be modest and humble enough to admit to themselves that more good ideas usually originate in the working level of a technical team rather than in the management level, which is almost continuously tied up with planning, budgeting, personnel, contractual and similar problems. Therefore, if good ideas originated in the working level of a large development organization do not find their way to the top, the team will go to seed.

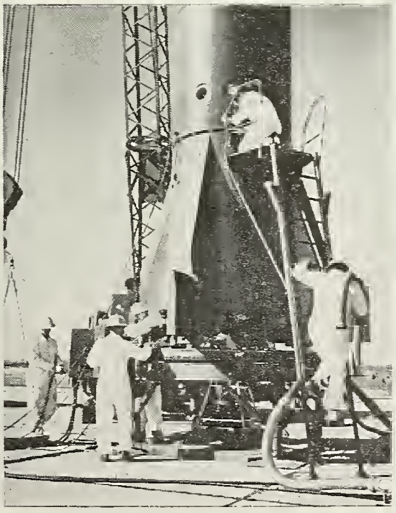
● **Loyalty, honesty and justice.** I am not using these well-worn terms just because you can't lose by stating that you are opposed to sin. There is a very practical aspect to these words in connection with a successful guided missile team.

One of our early Redstone missiles developed trouble in mid-flight. The telemeter records indicated that the flight had been flawless up to that instant, and permitted us to localize the probable source of trouble. However, the suspected area had been very carefully checked in numerous laboratory tests so that all explanations sounded highly artificial.

Several theories were advanced. Finally one theory was accepted as most likely and remedial action based on it was initiated. At this point an engineer who was a member of the firing group called and said he wanted to see me. He came up to my office and told me that during pre-launching preparation he had tightened a certain connection just to make sure that there would be good contact.

While so doing, he had touched a contact with a screwdriver and drawn a spark. Since the system checked out well after this incident, he hadn't paid any attention to the matter. But now that everybody was talking about a possible failure in that particular apparatus, he just wanted to tell me the story for whatever it was worth. A quick study indicated that here was the answer. Needless to say, the "remedial action" was called off and no changes were made.

I sent the engineer a bottle of champagne because I wanted everybody to know that honesty pays off, even if someone may run the risk of incriminating himself. Absolute honesty is something you simply cannot dispense with in a team effort as difficult as that of missile development.



ntenna operation, for launching preparation, for fueling, and for successful telemetry and guidance.

Indispensable Requirements

Loyalty and justice are just as indispensable. We must realize that every new development involves risk and the bigger the project, the greater are these risks. It would be conceited for the top management of a large development organization to believe (You sometimes hear statements to this effect!) that the man in the laboratory or behind the drawing board need not worry about the risk because the management alone is strong and brave enough to shoulder the responsibility.

Nobody can relieve a member of a team from his responsibility in his particular area. Moreover, the team member is usually quite proud of this responsibility and is only too ready to take it. But in a risky operation like a multi-million dollar guided missile project he wants to know that the management will back him up if he sticks his neck out and something does go wrong.

● **Finally a good team needs** a healthy rate of metabolism. In a dynamic team there must be chances for fair advancement for everybody. Without this chance the team will become stagnant and sterile.

The only way to maintain advancement chances is by providing a continuous influx of young people. This continuous influx of new blood makes the team less vulnerable to losses of key personnel, which may not only occur as a result of old age or death, but are unavoidable in a free economy. A healthy rate of metabolism should not be confused with personnel turnover, however. While the former is an indication of a healthy team, a high personnel turnover is a very definite indication that something is wrong.

There are only a very few experienced guided missile teams in existence in this country—experienced in the sense that they had an opportunity to see a complete guided missile system through from its early conception to operational readiness. These few coherent teams represent the greatest single asset this country possesses in the continuous struggle for international leadership in the guided missile field. Government agencies and corporations should spare no effort to protect the integrity of these teams and prevent them from disintegration and decay. This is a difficult task at a time when both the demands for better guided missiles and the willingness of industry to get into this new buisness is increasing at a much faster rate than organical growth of teams permit.

Temptations Are Great

Today the situation is such that anyone with a few years of experience in the missile business is continuously tempted to desert his team and accept a position of allegedly much greater responsibility (and, of course, much higher pay!) with one of the many companies that are desperately trying to establish themselves in the guided missile business.

I do not know of a greater single threat to this country's guided missile superiority than the danger of disintegration of the few experienced development teams under the onslaught of the gold-plated temptations offered by the fast-growing guided missile industry itself.

This is a free country. Unlike some of our competitors overseas we cannot, in peacetime, assign scientists and engineers to high priority projects and keep them there even if they don't like their jobs. It is the task of our guided missile project managements to *make* them like it.

But there is also an ethical obligation on the scientist and engineer himself. He should realize that every penny spent on guided missile development comes out of the taxpayer's wallet. In the research and development phase most guided missiles are not completely successful—but the missile itself will never learn what was wrong with it!

It is the development team that learns and widens its experience through failures in early missile testing. Consequently, any guided missile scientist and engineer playing with the thought of leaving his team should remember that he represents a public investment—not only as an individual and guided missile man—but as a member of his team. His value to the taxpayer may drop substantially if he changes his team allegiance. END.

A BOY AND HIS ROCKET

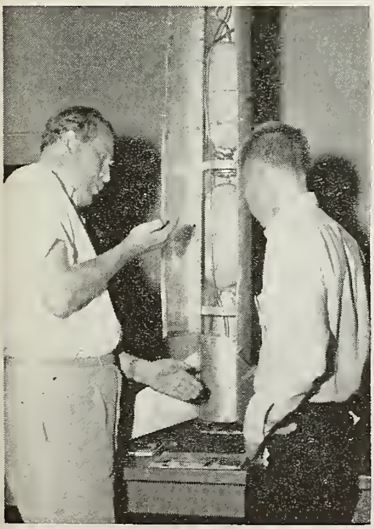
CHARLOTTE, N. C.—America's youngest rocket designer, ingenious 17-year-old Jimmy Blackmon, whose 6-foot gasoline rocket was "rejected" by Redstone scientists, is going to build another one.

"I won't build a whole missile as such," he told MISSILES & ROCKETS, "just the motor—with valve systems and injector head. Then I'll test the thing statically under 1,200 psi pressure with water and carbon dioxide to find out how I can mix propellants and control the flow into the injector head. I'll take some movies of the propellant flow and study the pattern."

Jimmy Blackmon's first rocket was rejected by the Army because high back pressure in the combustion chamber probably would have caused it to blow up.

● **The significance** of Jimmy's rocket experiments does not lie in the fact that this sort of thing can be experimented with on an amateur basis—and that our rocket-minded youngsters should be encouraged to convert a corner in the basement into a rocket lab—rather, the Blackmon case serves to focus attention on a problem that agitates the minds of many young American would-be rocket engineers.

Jimmy—and thousands of other youngsters—don't know what kind of prep-education is required for full-fledged missiles engineering studies later.



ROCKETEER VON BRAUN & JIMMY
. . . Too much back pressure

There Are Problems

Where do they start? What schools should they attend? What books should they read?

"I don't understand it," says Jimmy, "nobody can tell me exactly how I should go about becoming a missile engineer. Certainly, later on I should probably go to M. I. T. or Cal Tech or some similar university, but apparently I'm too young to even think about rocket hardware, or something. There are no books available; there is really no literature on actual design or construction of missiles and rockets."

He says there is no missile science or rocketry included in any high-school or college course.

● **"That's the reason** why I decided to start from scratch," he says. "It has taken me two and a half years to build this first rocket. The only available background information has been some basic dope on some early, unclassified rockets. I have read a lot of books on rockets, but either they don't tell you anything, or they are so technical you don't understand them. So it is quite obvious that there is no "in between" literature, something of an ABC or an introduction to "how to design a rocket."

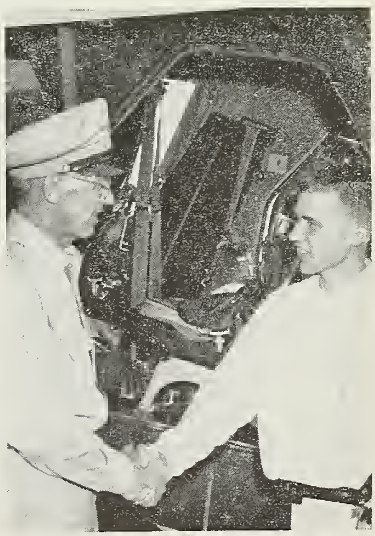
Jimmy's enthusiasm is admirable. One probably could not convince him that the art of rocket construction was never meant to be conducted in basements, even if the early pioneers did start out that way.

The fact remains that our high-schools and colleges might want to look into the vocational aspects for this new and continually growing technological area. In view of the tremendous recruitment programs of the industry, youth is becoming aware of the possibilities in the missile field, Jimmy thinks. They should get some guidance, he suggests. There should be some official or semi-official institution that could inform this country's would-be rocket engineers on how to plan for the future.

● "I am sure a lot of us teenagers waste a lot of time because we don't get any guidance with respect to what courses we should choose and what schools we should attend," Jimmy says.

"Furthermore, if the missile industry needs engineers so badly, why don't they let us start while we're young? I'm sure a lot of teachers would go ahead and suggest to us that we have to study the fundamentals of different sciences, and that's fine. But beyond that, I think many young boys already have so much missile and rocket know-how these days, if they're interested, that they could actually begin their applied studies much sooner."

Of course, most of our young would-be rocket engineers are not as realistic in their enthusiasm as Jimmy Blackmon. But they are still in the same position; they do not know where to go for guidance. Dr. Wernher von Braun, in his article in this issue of MISSILES & ROCKETS, points out that he receives many letters from young boys asking him "how to become a rocket expert." But it is too much of a job for one man to handle all these inquiries.



GENERAL H. N. TOFTOY
. . . Free advice to an amateur

NACA *what it's doing and where it's going*

By Dr. Hugh L. Dryden

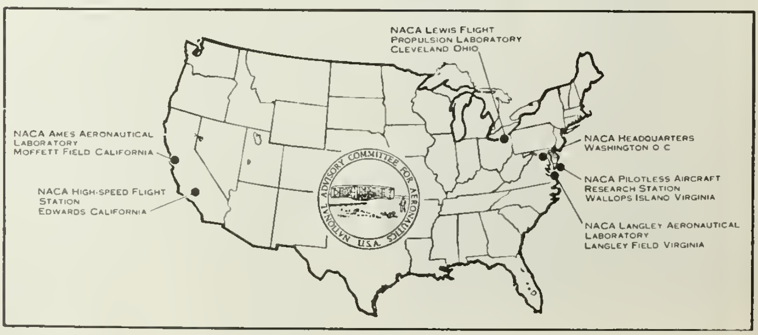
The National Advisory Committee for Aeronautics has extended its interests beyond the atmosphere to new types of vehicles in the search for ever-increasing speed and altitude. Performance goals have been boosted by an order of magnitude through the development of rocket propulsion. Increasing altitude made possible by rocket propulsion permits greatly increased speed, of course; and the attainment of the velocity required to escape from the earth's gravitational field is not too far away.

Rockets first appeared in the NACA in 1945 as a tool for research on transonic and supersonic aerodynamic problems. Available solid-propellant rockets developed during the war as ordnance weapons were used to propel models at high speed. Aerodynamic characteristics were measured by radio telemetry and radar techniques. Research on rocket engine problems began shortly thereafter at NACA's Lewis Flight Propulsion Laboratory.

● **The National Advisory Committee for Aeronautics** is appointed by the President. A 17-man Committee serves as a board of directors, establishing policies and programs for its paid staff of nearly 8,000 Civil Service scientists, engineers, technicians and other employees. Ever since its establishment by Congress in 1915, with the assigned responsibility "to supervise and direct the scientific study of the problems of flight with a view to their practical solution," the agency has been keenly conscious that it is financed by Congressional appropriation, and that it is operating for the benefit of the taxpaying public.

Using both theoretical and experimental techniques, NACA works always towards the goal of discovering how to make better aircraft. With the advancing goals of flight performance, NACA has proceeded from subsonic to supersonic piloted aircraft, to pilotless aircraft, guided missiles, and ballistic missiles. Congress has placed no restrictions of distance, or speed or altitude.

Some of the research effort is basic and long-range. Here the scientist is seeking discovery and understanding. Often the worker himself cannot foresee the possible applications of his studies, or evaluate their true worth. The path between basic or long-range research and the finally-developed product is



NACA Research Centers

seldom direct. This kind of research activity may continue to result in improvements in many products. It is, of course, possible to guide even this long-range kind of research into areas which bring productive results to a given technological field.

At the other end of the spectrum is what might be called applied research of shorter time scale. Very specific goals are set for groups of scientists and engineers conducting research directed towards early application. In performing this kind of work, it is necessary to draw upon all the existing knowledge which has been obtained by basic research.

● **During its first 25** years—until World War II—most of the NACA's research was concentrated on aerodynamic problems. By taking bold action to provide its scientists and engineers with the novel, often complicated, and usually expensive research equipment necessary to press forward the frontiers of aeronautical science, the NACA produced a wealth of information that was used to good advantage by America's aircraft industry. This was a course of action that paid handsome dividends, in directly useful information, on the taxpayers' investment.

The Author . . .

is the well-known Director of the National Advisory Committee for Aeronautics. He has been the responsible head of this agency since 1947. Dr. Dryden majored in physics at Johns Hopkins University, where he was graduated with honors in 1918. The following year he earned his Ph.D. from the same university. He holds seven honorary degrees from as many institutions of higher learning.

We were living in a peaceful, subsonic world. Supersonic speeds were of interest only to ballistic experts and to the few enthusiasts who wanted to travel faster than would be possible in propeller-driven aircraft.

Dreams Come True

But almost imperceptibly, technological advances were made that in their sum transformed such unattainable dreams as rocket engines into practicable ideas. These technological gains were in many areas —metallurgy, fuels, chemistry, combustion, electronics, aerodynamics.

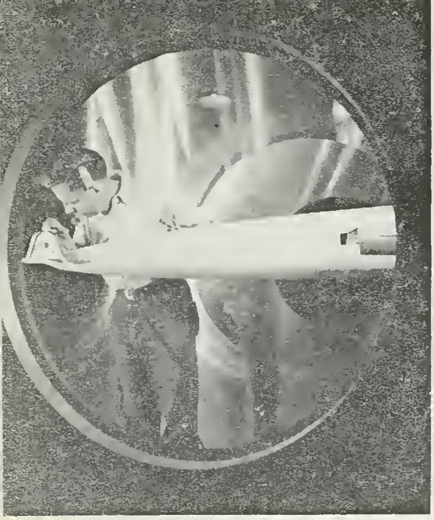
The NACA's effort in World War II was devoted largely to applied research, the business of finding "quick fixes" to improve the performance of existing airplanes and to make production engines more powerful. Fortunately, years of research had produced a sizeable backlog of readily usable design data on low-drag wings, high-speed propellers, stability and control, improved systems for cowling and cooling engines, and the like. During the war years, the NACA worked on more than a hundred airplane types.

By the close of World War II, the end had come for development of the airplane as conceived by the Wright brothers. Now, it was possible to build useful rocket engines, and with this development came the possibility of flight at velocities exceeding the speed of sound and to altitudes higher than the earth's atmosphere.

● **The problems implicit** in the speeds now within man's grasp covered the usual, accepted aspects of aeronautics—aerodynamics, structures and loads, powerplants—plus new ones, thermo-dynamics, aerothermo-chemistry.

Instead of thinking of speed in terms of hundreds of miles an hour, it became necessary to stretch one's imagination to encompass the prob-

Staff member of the 4 x 4-foot supersonic pressure tunnel at Langley Aeronautical Laboratory of NACA checks model of research missile in test section of tunnel. Highly-reflective walls of test section are constructed of stainless steel.



Forward section of a research missile viewed through the 26″ diameter Schlieren window in NACA 8 x 6-foot supersonic wind tunnel test section. A technician is calibrating remotely controlled surface of missile.

lems growing from flight measured in thousands of miles an hour. For such speeds the rocket engine is peculiarly fitted and indeed necessary.

The earliest NACA research on rockets deal with liquid-propellants, exploring the possibilities of known compounds and of new chemicals synthesized for the purpose to give much higher performance than the alcohol-liquid oxygen of the V-2 rocket. The first work was that of theoretical computations of performance, soon followed in 1947 by experimental work in small rockets of 100-lb. thrust.

Expanding Research

Within a year experiments were in progress on rocket starting at low temperatures and pressures corresponding to high altitudes, on film cooling of the combustion chamber walls, and on photographic studies of combustion in a transparent rocket chamber. Today, research continues in propellants, materials, combustion, and cooling in facilities permitting the use of engines of larger thrust and in other fields which promise to contribute to the improved performance and utility of rocket propulsion.

The tremendous increases in speed and altitude made possible by rocket propulsion can be realized only by the simultaneous solution of many difficult aerodynamic and structural problems of the vehicle, whether aircraft or missile. High speed through the air generates heat which raises the temperature of the aircraft or missile, producing thermal stresses and loss of strength or even melting of the materials of which the structure is made. Aerodynamic heating can be avoided by going above the atmosphere—except that always we have to re-enter the atmosphere to reach our destination or target.

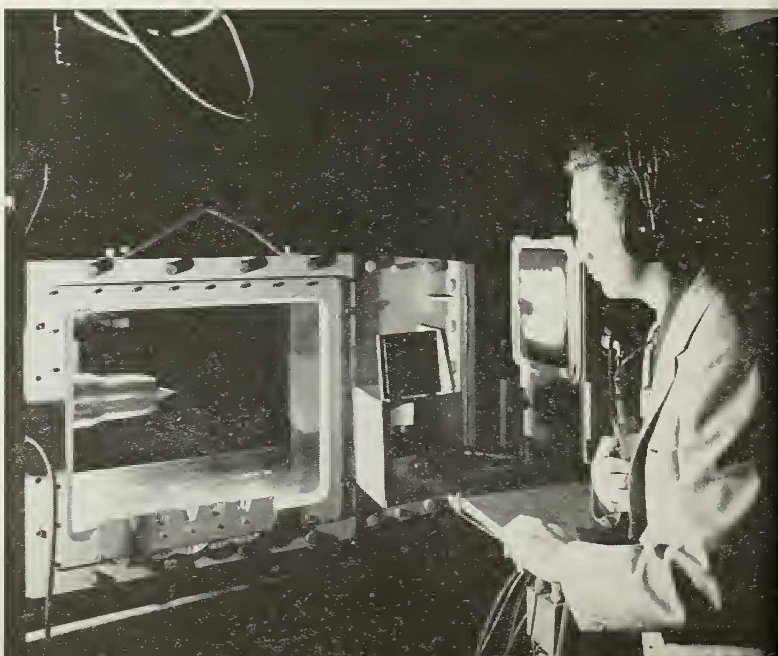
The re-entry of the nose cone of a ballistic missile is confronted with the most severe conditions. Dissociation of air molecules into atoms and the recombination of atoms, ionization of the atoms and recombination of electrons and ions, and the formation of new chemical compounds from constituents of the air—these are areas where our understanding is sadly incomplete.

● **What makes research** on such "out-of-this-world" problems so difficult is that we have had to learn how to duplicate in the laboratory the extremely high temperatures and the other conditions of future flight. Only recently have we begun to see how to design and build small, pilot models with which to prove the practicability of constructing the radical new research tools so necessary for rapid expansion of the limits of our fundamental knowledge. Much work remains to be done in this stage, the providing of tools with which to study the basic problems.

Research and development have proceeded simultaneously from the days by the design and construction of practical devices, enabling us to focus research on the important problems of applied research which lead to advances in the technology. Along with this applied research we do basic research in hypersonic aerodynamics, new fuels, combustion, and heat transfer under the extreme environmental conditions which lie in the future.

This even now, while so much remains to be done toward providing the tools required for research at the limits of technology, very large effort is being devoted to the development of prototypes of actual long-range rocket missiles. Next year, according to present commitments, we are scheduled to fire a satellite vehicle hundreds of miles into the sky. With this event, we shall open the gates to the vistas of space. END.

Conical inlet being tested in 18 x 18-inch NACA supersonic tunnel.



NACA's *DAN* EXPERIMENT

National Advisory Committee for Aeronautics has disclosed first details of successful flight tests using a combination of a *Nike* missile booster and an Allegheny Ballistics Laboratory *Deacon* sustainer as a two-stage, solid-propellant rocket for meteorological sounding at extreme altitudes.

Two test firings of *Deacon-Nike* (called Dan) rockets indicate that altitudes between 385,000 and 487,000 ft. (73 to 92 miles) may be reached with payloads ranging from 60 to 10 pounds, NACA says.

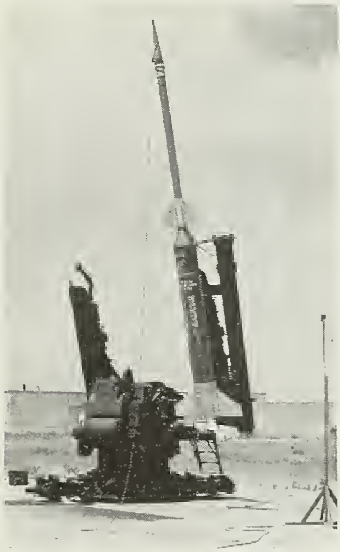
Project was conducted for the U.S. Air Force's Cambridge Research Center by NACA's Langley Aeronautical Laboratory. Actual firings took place at its Wallops Island, Va. Pilotless Aircraft Research Center late last year.

In the NACA tests, the first *Deacon-Nike* was launched at a 75° angle of elevation and reached a peak altitude of 356,000 ft. some 161 seconds after launching Second Dan rocket, launched at the same angle, attained a slightly lower altitude of 350,000 ft. in 156 seconds. But NACA scientists estimate the higher altitudes can be reached by launching the Dan vertically.

● **Design of the sounding rocket** was worked out by NACA in conjunction with University of Michigan's Engineering Research Institute. In final form, it consisted of a first-stage *Nike* booster with a second-stage ABL *Deacon* sustainer, the latter having been used previously by NACA as an aerodynamic research vehicle.

Test results showed that on each flight this combination operated entirely satisfactorily with respect to both propulsion and aerodynamics.

Ultimate purpose of the vehicle is to carry free-fall accelerometer sphere apparatus developed by the University of Michigan for measuring densities at heights between 250,000 and 375,000 ft.



Dan rocket ready for launching.

Test details, reported in Technical Note 3739 by NACA's R. H. Heitkotter of Langley Aeronautical Laboratory, show these weight specifications for the Dan rockets:

Component	Weight (lbs.)
Loaded *Nike* booster	1,170
Booster adapter	45
Booster fins	109
Complete booster	1,324
Loaded *Deacon*	151.5
Deacon fins, shroud & fairing	25.5
Nozzle extension	5
Nose cone and instrumentation	34
Complete *Deacon*	216

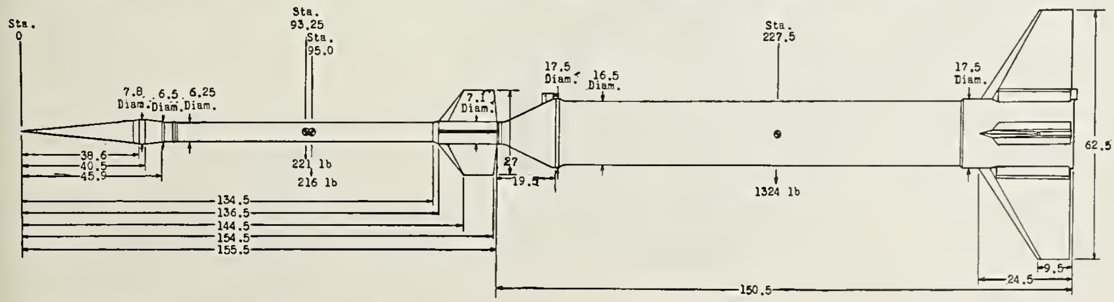
Nose cone of the *Deacon* housed AN/DPN-19 radar beacon instrumentation protected from aerodynamic heating by a 3/16-in. thick magnesium shell. The beacon signal was tracked by an NACA modified SCR-584 CW Doppler radar to obtain data on variation of speed with time for computing Mach number.

Procedure used in both tests was to allow the second-stage rockets to decelerate after *Nike* booster separation in order to reduce nose cone and rocket case wall temperatures by traversing the lower, denser atmosphere at relatively low speeds.

First Dan rocket was carried by *Nike* booster to 4,900 ft. before first-stage separation. It coasted 13.7 seconds before the *Deacon* sustainer rocket was fired and accelerated to a maximum velocity of 5,150 feet per second (approx. Mach 5) at an altitude of 47,060 ft.

After burnout, the *Deacon* coasted in free flight until the nose cone and sphere were released about 52 seconds after launching. Peak altitude of 356,000 ft. was determined from the radar beacon equipment in the nose cone 161 seconds after launching.

Second vehicle was boosted to 5,200 ft., coasted 9.45 seconds and was accelerated to a top speed of 5,289 fps at an altitude of 39,339 ft.



DEACON-NIKE rocket. Accelerometer sphere is located at bulge in Deacon immediately aft of nose cone (left).

Navigation by Satellites

By Lovell Lawrence Jr.

An Artificial Satellite Time and Radio Orbit celestial navigation system that is simple, yet reliable, may be feasible in the near future. To accomplish this, however, a very high degree of accuracy must be maintained in the electronic components. Methods for observing this high-velocity body by other than optical means will be necessary, and accurate time signals must be generated.

To utilize a stable celestial body for navigation purposes, it is necessary to know the co-ordinates of its sub-astral position at any given time, and to be able to accurately associate it to geographical locations on the earth. The orbits selected for artificial satellite around the earth, to be used as a navigation reference, should be permanent and circular (or near-circular) with an altitude that will allow visibility over the greatest area at all times. Some perturbation of the satellites and precession of the orbits due to the earth's oblateness can be tolerated, provided that these changes are slow and predictable.

Considering a 24-hour equatorial orbit, the satellite would rotate at the same rate as the earth and appear to remain motionless over one spot at all times. A proper number of these artificial bodies placed in such orbits would permit continuous navigation over the earth's surface and would greatly reduce complexity in the preparation of almanac records. However, the 24-hour orbit can be disregarded at the present time since the advancement in the art will not develop rapidly enough to permit the launching of such a satellite in the near future.

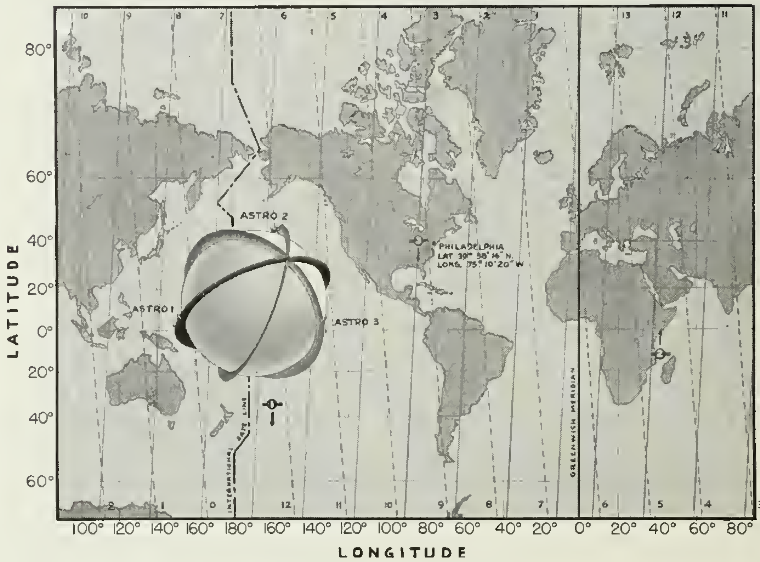


Figure 1—Mercator projection with three ASTRO satellites in their period positions eight hours apart.

● **The fact that** very delicate and complicated instruments will be necessary to maintain accurate contact with the satellite makes the venture difficult. Also, the requirement for increased power to maintain high visibility, and the difficulty that would be encountered in order to correct for large refraction errors caused by atmospheric and ionospheric disturbances would make its use untenable. Therefore, a lower-altitude orbit seems more feasible right now.

The placement of a 105-minute orbit seems possible in the predictable future, and this 600-mile altitude vehicle will establish a horizon that will allow the satellite to be visible to an observer for periods of from 6 to 16 minutes at any point

Figure 2—Estimated satellite specifications.

	Non-Directional	*Spin*
Satellite diameter maximum	3.5 ft.	3.5 ft.
Sphere weight	25 lbs.	25 lbs.
Transmitter	100 watt-10 lbs.	15 watt-5 lbs.
Power generator	12.5 watt-15 lbs.	2 watt-5 lbs.
Antenna	8—8 lbs.	1—1 lb.
Gyro	None	5 lbs.
Jet system	None	10 lbs.
Total weight	58 lbs.	51 lbs.

on the earth's surface. Three of these orbits, symmetrically placed over the poles, will permit a navigation fix at intervals of not more than 105 minutes decreasing generally toward the poles. Also, at this altitude, a satellite velocity in the order of 4½ miles per second would be expected, thus permitting the use of the *Doppler* frequency shift of a carrier on the satellite as a means for determining its relative velocity and by correlation, the position of the navigating vehicle.

● Figure 1 shows a *Mercator* projection of the world, with the three Astro units in their period positions eight hours apart. The time lines of Astro-3 are plotted, showing the co-ordinates of its sub-astral position, 21 hours after launching. The other two Astros are shown in their positions at the same hour. However, their time lines have been omitted to maintain clarity in the chart. Astro-3 will be used later when the aircraft flight plot is discussed.

To be assured of a good polar orbit, the satellite should be launched from the North Pole on the proper trajectory so that it is injected into its predetermined orbit.

It should be noted that the Astro system could readily be combined with satellites used for collecting geophysical data. However, for the purposes of this article, only the navigational application will be considered.

Satellite Designs

Two satellite designs are considered, both spherical in shape. One to be oriented, by gyroscopic means, into the plane of its orbit after being launched, spinning at the time of cutoff. The other design would be placed in its orbit without any attempt to control its altitude.

The Author . . .

is a recognized authority on rocket powerplants and missile design. He founded Reaction Motors, Inc. and served as its president and chairman of the board until 1951. A former president of the American Rocket Society, he joined Chrysler Corp. Missile Operations in 1954, where he is now Assistant Chief Engineer.

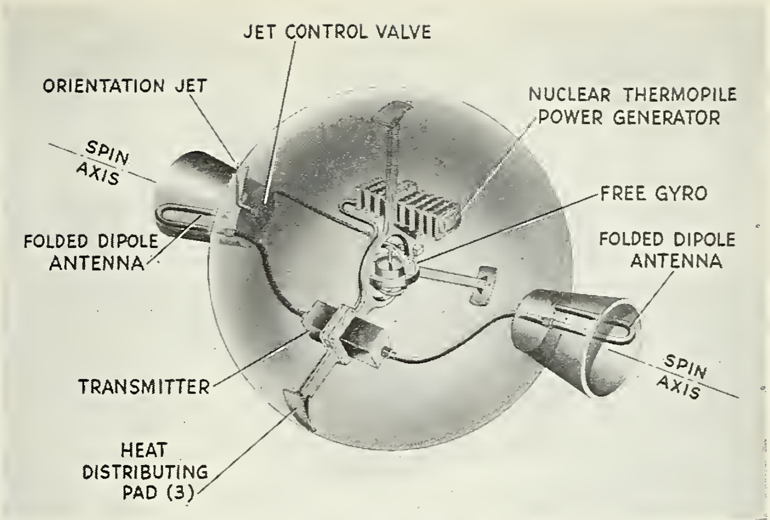


Figure 3—Reoriented satellite with spin.

The general dimensions of the satellite shown in Figure 2 are more or less determined by the minimum surface area required to dissipate the 200 watts of heat from the thermoelectric generator. It is believed that the volume of the two-foot sphere will be of sufficient magnitude for housing the necessary equipment.

● It is conceived that the reorientated satellite would be launched with its spin axis directed into the flight path of its trajectory, in the same manner that an artillery shell is fired, Figure 3. After a predetermined time in the orbit, the gyro would signal the jet to force the sphere around until its spin axis was perpendicular to the plane of the orbit and it coincided with the gyro spin axis.

Such momentum as may be created by the gyro running down would then be absorbed into the satellite spin axis as an increase in its spin rate. To establish a proper wave pattern for broad coverage over the earth, two folded dipole antennas would be placed at a proper angle to the axis of spin, and the resulting pattern would laterally sweep the earth, back and forth, as the satellite moved along.

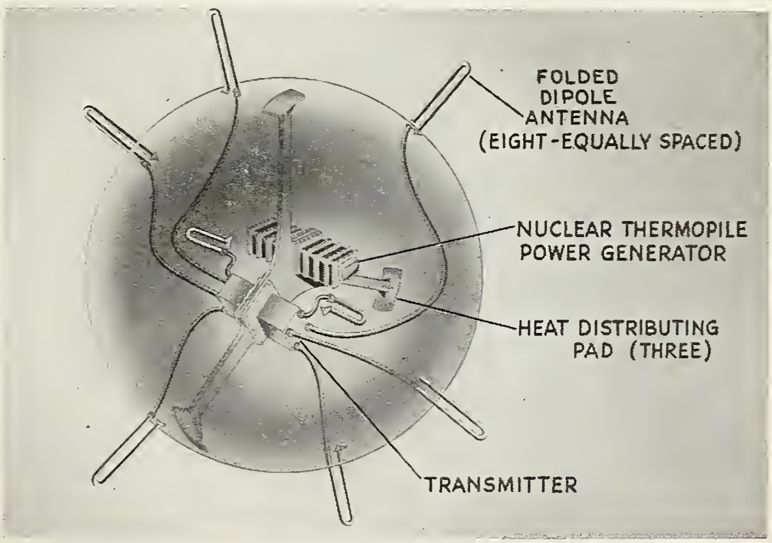


Figure 4—Non-directional satellite with eight antennas.

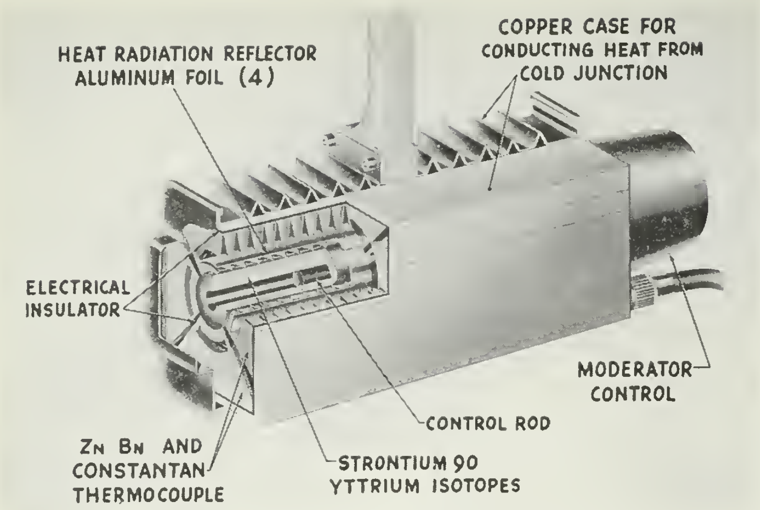


Figure 5—Thermopile satellite power package.

The folded half-wave dipole allows the use of metal sphere construction in order to contain the transmitter, gyro, power pack and high-pressure gas supply for the reorientation jet. This sphere then becomes the common ground for both antennas. Although each antenna will establish its own wave pattern, for all intents and purposes all patterns will appear to the earth as if they emanate from a single dipole.

● Figure 4 shows the satellite with an antenna system for producing an all-directional wave pattern, using eight symmetrically-place folded dinoles arranged to permit good earth contact, irrespective of orientation or spin. The same arrangement exists except for a slightly larger powerpack and transmitter, excluding the gyro-jet reorientation system. The bracket used to attach these items to the inside of the satellite's sphere would be made of material with high conductivity so that heat may be rapidly removed from the powerpack through radiation into the void from the blackened outer shell of the sphere.

In addition to the heat-conducting frame and pads, the sphere will be charged with a liberal supply of mixed nitrogen and hydrogen gas. This mixture will materially assist in damping extreme temperature variations when the plane of the satellite's orbit was perpendicular to the sun's rays.

The nondirectional radiating satellite will require approximately 12½ watts of electrical energy to produce 15 watts of power in each of the eight antennas at 100 mc. This ratio of low-power input for high-power output is accomplished by utilizing a radar-type pulse, with a fixed width of around ten microseconds. The pulse-spacing will then be varied by an accurate and periodically-corrected timing oscillator, and used to indicate the lapsed time of each orbit period. To produce this 12½ watts of power for the transmitter, a nuclear thermopile could be used.

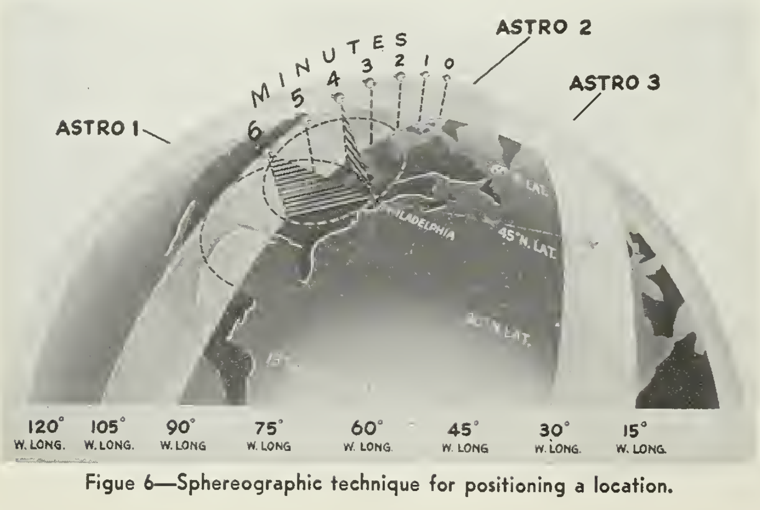
● The isotope to be used for the thermopile heat source calls for four pounds of strontium 90 that produces 200 watts of heat. Its half life is 20 years. This power source would also be suitable for heating the oven containing the transmitter, which maintains the high degree of accuracy required of the master oscillator crystal and timing circuits.

In view of the complexity of any other type of power package, such as a sun generator requiring controls to maintain its proper orientation with respect to the sun, the use of a thermopile seems feasible. Figure 5. Present thermocoupls of antimony-bismuth alloys and constantan will produce about one-tenth volt, with a 400-degree centigrade temperature differential between the hot and cold junctions, and reach an efficiency of about five percent.

Navigating with Astro

To give some idea of the Astro system of navigation, Figure 6 depicts, graphically, a sphereographic technique for determining the position of a location on the earth with reference to the orbit at some given time. Since this form of celestial navigation is in common use today, with standard almanac tables of the stars prepared in advance, it will not be necessary to discuss its technique in detail.

For the sake of clarity, it is assumed that Astro-2 was recently launched from the North Pole and aimed along the Greenwich Meridian. If 5½ hours have elapsed, the satellite has then made 3.14 revolu-



Figue 6—Sphereographic technique for positioning a location.

tions. Since the 105-minute orbit makes approximately .57 revolutions per hour, this means that at approximately 5:15h it would be directly over the North Pole.

● **For example:** If a ship, moored in the Philadelphia Harbor, were equipped with an electronic sextant (consisting of an accurate and highly-directional antenna coupled with a pendulum for defining the horizon), it would be able to determine the satellite's altitude angle as it came into range. By referring to the almanac (to determine the satellite's sub-astral point), a line of position could then be worked out for the ship. The circle of equal altitude, established from this position, would show that the ship must be somewhere on this circle.

If another observation were made some minutes later, a second circle of equal altitude could be similarly determined. After observing the azimuth roughly, the intersection of these two circles would determine the ship's actual position, or fix.

The difficulty with the sphereographical navigation technique applied to the Astro system is that an accuracy of five places is required of the tracking mechanism in the electronic sextant. To develop reliability in such a mechanism would be difficult indeed—especially since serious errors will be introduced when the ship is pitching and rolling—resulting in poor correlation between the horizon reference and the observed angle of elevation. It is clear that a different method of navigation will be necessary to eliminate this complicated and expensive approach.

Doppler Shift

Since the velocity of a 105-minute Astro is in the order of 16,500 mph, it may be measured by observing the doppler frequency deviation of the 100 mc carrier. It is this *Doppler* shift phenomenon that makes the sound of a train whistle appear to change its pitch as it passes by. This same phenomenon is also applicable to radio waves. If the difference in frequency deviation can be detected between a satellite on an orbit passing directly overhead and an orbit observed at a distance, the relative velocity thus derived is a measure of the position distance with respect to the observer. A direct correlation can then be made between the frequency measured from the line of closest approach (or null) for each increment of lapsed time, and the required position distance in degrees of longitude or in nautical miles.

● Figure 7 shows a plot of the observed frequency deviation, versus position distance, for a number of minutes of lapsed time after the satellite has passed the sub-astral latitude position. Above this graph are shown three of the family of orbits, graphically portrayed in increments of longitude by placing them over lines that are tangent to the earth's surface. The intersections of the arcs at the tangent lines determine the Astro's visible horizon to an observer who is at the tangent position on the zero longitude line. The orbit directly overhead will remain in view 16 minutes, the most distant orbit for 6 minutes.

The line drawn perpendicular to the tangents of the horizon on these three orbits passes through the position of closest approach where both the satellite's apparent velocity and the *Doppler* shift will reach zero. Then, to obtain the accurate time of the zero beat (or null) and the correct position distance of the observer from the satellite, it will be necessary to have a computer capable of rapidly making a series of approximations. As each approximation is made, the computer corrects for the known velocity com-

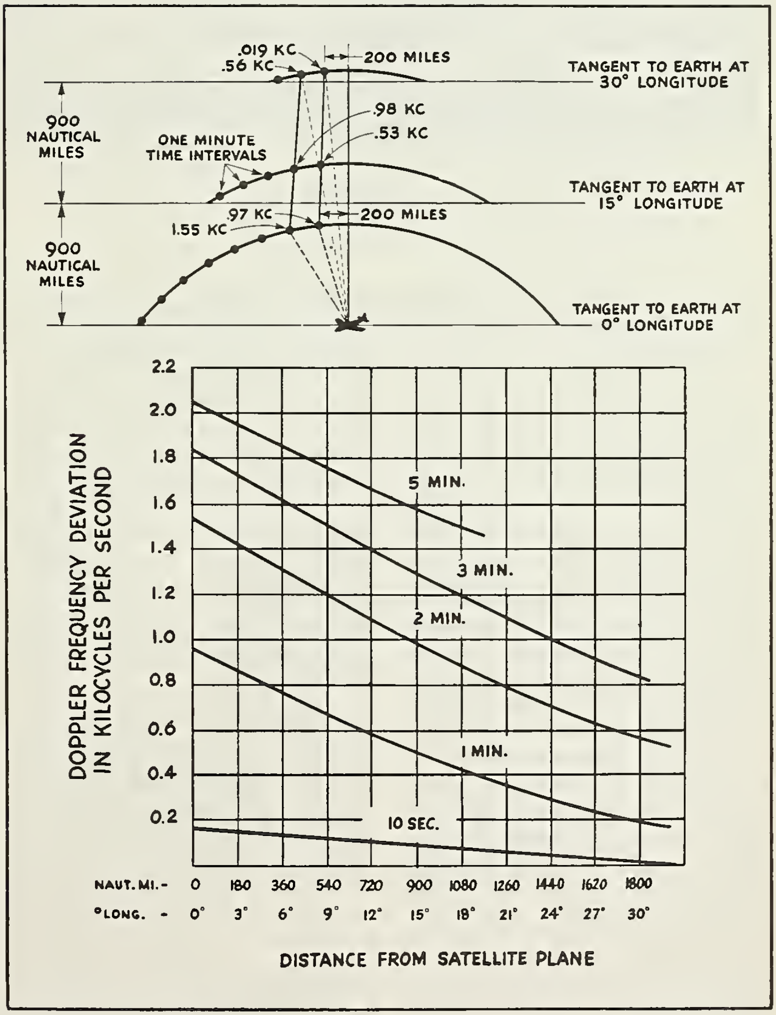


Figure 7—Plot of observed Doppler frequency.

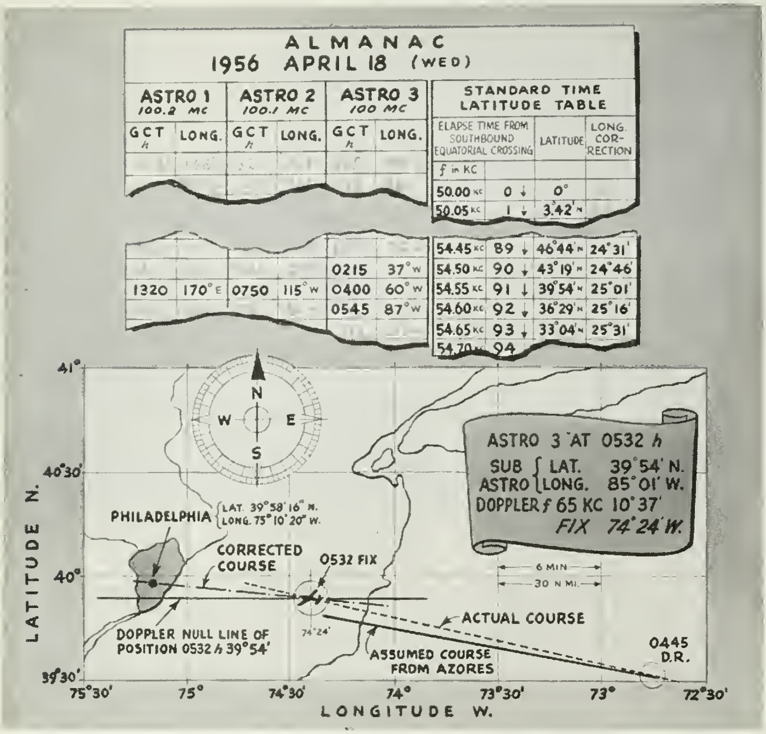


Figure 8—Depicting a flight from the Azores to Philadelphia on a Mercator position-plotting sheet.

ponent of the earth's rotation, as well as air speed, course heading and altitude; thus shrinking the error.

If the computer is allowed to function for a reasonable time after the apparent null is detected, then the corrected null and position distance are obtained, and the observer can establish a fix with a fairly high degree of accuracy. If the phase shift of the beat frequency (as it reverses at null) is detected by a phase discriminator, it is estimated that the geographical position of an observer can be determined within an accuracy of one mile by holding the satellite carrier frequency to ten cycles in 100 million.

● **As an example:** If an observer were to neglect all motion and attitude other than that of the satellite, and a frequency shift of .53kc was indicated one minute after null, then (according to the graph) he would be at longitude 15°, or 900 nautical miles from the satellite. If another observation was made at the end of the second minute, the same reading would be obtained.

Figure 8 depicts an aircraft flight from the Azores to Philadelphia on a *Mercator* position plotting sheet. Since it is probable that no Astro will fall exactly into its predetermined orbital altitude and, because each one is launched at different intervals, all these orbits must be recorded for each day of the year. The almanac page shows the Greenwich Mean Time and longitude of their sub-astral position as the satellites pass over the equator. There will be approximately fourteen 105-minute periods of revolution to be listed for each day of the year.

The column at the right of the double line is the Standard Time latitude table for each minute which is always predictable for any permanent orbit period of revolution. This table could be placed on the inside cover of the almanac; but, to make for simpler reference during this discussion, both tables are placed side-by-side. Since it is also necessary to establish Astro-3's longitude coordinate for each increment of time from its last southbound equatorial crossing, this last column on the right gives the correction to be applied.

● **The Astro's** transmitter sends a time reference signal by varying the pulse spacinb, indicating the lapse of time for each rotational period.

An oscillator, modulated by an accurate timer and corrected every 105 minutes as the satellite passes over the North Pole, will vary between 50 to 55 kc as each minute has elapsed. This variation, when properly interpreted once the Astro has been calibrated, will produce directly the latitude coordinate as well as the correction for the longitude coordinate. It would then be possible to introduce this signal into the computer as a function, without further reference to a table.

The *Mercator* position plotting sheet shows aircraft has been in flight in dense fog for a number of hours, and a dead reckoning plot was made at 14:45 hours. The course has been continued until 05:05 hours, when the Astro-3 signal was detected. After listening to the drop in pitch of the beat frequency between the satellite's transmitter and the receiver's oscillator, (while properly determining the azimuth), the apparent null occurs at 05:31 hours.

After the computer is allowed to operate for one minute, the receiver tells us that 91 minutes have elapsed since the satellite's last equatorial crossing, and the corrected position distance is 10°37'. Now, upon referring to the standard table, the satellite's sub-astral latitude coordinate is 39°54'N. If the longitude correction of 25°01' is added to the longitude figure of 60°W (derived from the almanac table after determining the Greenwich time of the satellite's passage over the equator), then the sub-astral coordinates of the satellite are established.

By drawing an Earth Parallel from the satellite's sub-astral point on Mercator position plotting sheet, the observer can define his line of position. By subtracting the corrected position distance of 10°37' from the satellite's sub-astral longitude coordinate, an accurate fix is made at longitude 74°24'W on the latitude 34°54'N line of position. The navigator can now correct his course. END.

Martin's TITAN project

By Henry T. Simmons

Denver residents will be hearing a new sound not so many months from now. It will resemble the low rumble of a freight train in the far distance.

But it won't be a freight train. It will be the shattering exhaust of a rocket engine doing its stuff on a test stand tucked away in a Rocky Mountain canyon many miles to the southwest of the city.

Though distance and the natural acoustical effects of the mountains will soften the engine's blast to a gentle murmur, the sound will nonetheless signify a new era for the military potential of the United States as well as the economy of the Colorado capital.

With construction of its new plant near Denver racing to completion, the Martin Co., Baltimore, Md., may begin preliminary manufacturing operations before the end of this year on the airframe of the *Titan* intercontinental ballistic missile.

Titan is Martin's entry in Uncle Sam's forced-draft program to achieve a ballistic vehicle capable of transporting a thermonuclear warhead at least 5,000 miles. Its chief competitor is the *Atlas* ICBM vehicle which Convair Division of General Dynamics Corp., is building.

The Baltimore aircraft company and Convair are two of 16 major contractors engaged in the Air Force drive to develop and introduce the so-called "ultimate weapon" ahead of Soviet Russia. The other companies are working on complex guidance techniques, immensely powerful rocket engines and nose cones which must withstand terrific temperatures in bringing the thermonuclear payloads back through the atmosphere after their brief journey in space.

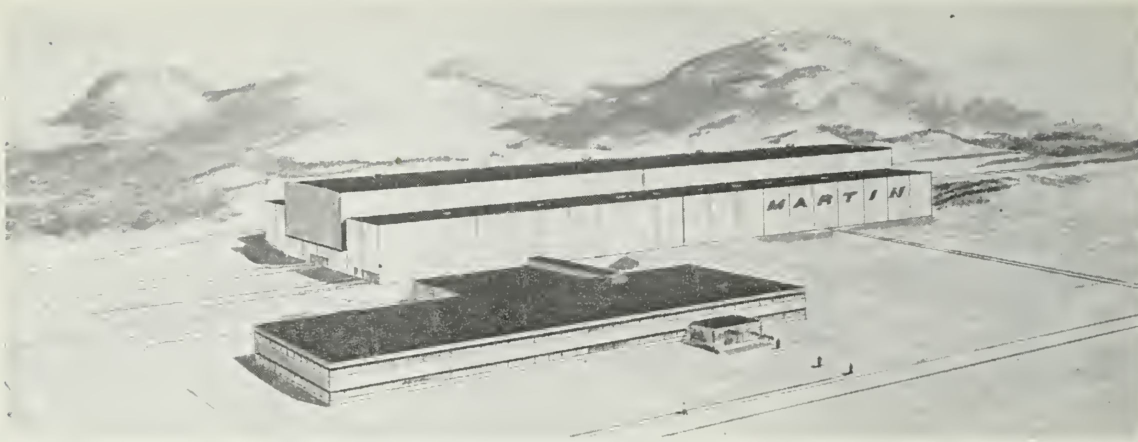
● **As expected,** details of the *Titan* are shrouded in military secrecy. But Dr. Walter Dornberger, formerly commander of the German V-2 rocket center at Peenemunde and now a missile consultant for Bell Aircraft Corp., has given this rough description of the ICBM: It will be more than 100 feet long, some feet in diameter and will weigh several hundred thousand pounds when fueled.

Though only an approximation, this description does suggest something of the magnitude of the job facing Martin's new Denver Division, set up early this year to develop and produce the *Titan* airframe. Work on its new facilities is running well ahead of schedule, according to local reports. All buildings are scheduled to be ready by January 1, less than one year after the start of construction, and some portions of the plant may be available as early as November 1.

Martin Investing $10 Million

Martin is putting $10 million of its own funds into the *Titan* project, which will occupy a 4,400-acre site in the "front range" of the Rocky Mountains in the vicinity of Waterton, Colo., about 20 miles southwest of Denver. A total of 408,300 square feet of plant space is now under construction, including a complete and modern factory of 306,700 square feet, an administration and engineering building of 88,400 square feet and a cafeteria of 13,200 square feet.

Supporting facilities include a steam plant with a capacity of 84,000 pounds of steam an hour, a 300,000-gallon water tank, an incinerator and plants for garbage disposal and sewage treatment. A parking lot with space for 750 cars is also planned, but this will undoubtedly have to be expanded as the plant builds up to its anticipated maximum of 5,000 employees by



Martin's New Denver Facility for Titan ICBM Development.

1960.

● Martin is also building a number of test stands for checking out engines and other systems of the completed ICBM weapons prior to their shipment for test firing or to storage in regular launching sites. The *Titan* test facilities will be located in canyons surrounded by high mountains so that the ear-splitting noise of the engine tests, according to the Denver University Research Institute, will be largely dissipated in the immediate area.

Construction Work Under Way

Meantime, construction work on access roads and bridges by State and County authorities is keeping pace with work on the Martin project itself. Ultimately, this work will have a most important bearing on the *Titan* operation since transportation of the huge, unwieldy missiles will be an acute problem. Barring accidents, it is unlikely that a *Titan* will ever leave the factory under its own power.

General Manager of the *Titan* project is Albert L. Varrieur, 39, a veteran Martin engineer and operations manager for a number of important company projects, including the B-26 bomber of World War II, the 404 commercial airliner and the P6M-1 jet flying boat.

Chief Engineer of the Denver Division is William G. "Mister Viking" Purdy, 38. He joined Martin in 1941 and became project engineer for the company's *Viking* research rocket program in 1947. He held that post until his promotion to the Denver position.

Varrieur and Purdy were among a nucleus of 249 Martin personnel who moved to Denver early this year to make ready for the day when the division's new facilities would be ready for use. Until that time, the Martin people are occupying four interim facilities in Denver: the Shell Building, the Keith Building, a manufacturing facility and a laboratory located in the suburb of Englewood.

● Other key personnel of Martin's Denver Division include Roy G. Andrews, Manager of Industrial Relations; Robern N. Blakey, Manager of Manufacturing; Dan L. Burford, Division Counsel; Hugh P. Campbell, Manager of Quality Control; Don P. Herron, Supervisor for Information Services; Ross B. Hooker, Director for Procurement and Facilities; Thomas P. Hudock, Division Controller; William C. Ruckert, Manager for Customer Relations; Robert G. Swope, Manager for Master Planning; Charles H. Williams, Jr., Director for Service and Test; James L. Burridge, Assistant Chief Engineer, and George Derr, Engineering Administrator.

Principal engineers include William E. Brown, Guidance and Control; John D. Goodlette, Airframe; Walter O. Lowrie, Flight Mechanics; Marvin Pitkin, Operational Engineering; Beal M. Teague, Ground Support; Harrison C. Wroton, Test and Reliability, and John R. Youngquist, Propulsion.

Why Denver Was Picked

Martin selected Denver as the location for its new division after a study of 94 cities in 33 states. It gives no less than 10 reasons for its choice:

1. Denver is a metropolis in a remote area.
2. The Rocky Mountain terrain is conducive to the testing of powerful engines.
3. Labor situation is good.
4. The climate is such that many people—including engineers—are willing to work in Denver on a permanent basis.
5. Colleges and universities in the area are exceptionally good.
6. Adequate rail, motor and airline transportation.
7. Sufficient fuel, gas, electricity and water supplies.
8. Highly cooperative attitude of the State and County highway departments.
9. Cooperation of the Chamber of Commerce and other civic organizations.
10. The area affords the high degree of security essential to the job of developing and producing ICBM weapons.

Martin is not the only aircraft-missile company in recent years to fall under the spell of Denver and the surrounding area as a desirable site for industrial operations.

Four other companies are already at work or building facilities there. They are Stanley Aviation Corp., Sundstrand Aviation Division of Sundstrand Machine Tool Co., Beech Aircraft Corp. and Ramo-Wooldridge Corp. The last company, incidentally, is technical monitor for the ICBM program for the Air Force, but it is prohibited under the terms of its contract from supplying any of the hardware for the weapon.

we can build a moon rocket NOW

By Kurt R. Stehling and Richard Foster

As a result of recent openly discussed progress in rocket research, it is now feasible from an engineering standpoint to send a solid-propellant rocket vehicle with a small payload to the moon.

Lunar rockets have been discussed openly for many years. But the usual schemes have involved large multistage vehicles beyond contemporary engineering feasibility.

It is quite probable that an attempt will be made to launch a moon rocket—or a circumlunar orbiter—when ICBM hardware is operational and available. Some scientists are inclined to think that such ventures may be realized in 1959-60. However, a smaller experimental vehicle can be built now.

In this article, which is based on a paper presented at the International Astronautical Federation Congress in Rome last month, Kurt R. Stehling and Richard Foster explain how a low-cost small lunar rocket program could be launched. The authors' plan is certain to arouse world-wide interest.

When carried aloft to 70,000 feet by a huge four-million-cubic-foot *Skyhook* balloon, a solid-propellant step-rocket will be capable of bringing a four-pound payload to the moon.

The booster vehicle needed for this task consists of a cluster of three large solid-propellant units with a total impulse of 472 x 10^4 lbs./sec. On top of this first-stage unit is mounted a second-stage solid-propellant rocket with a total impulse of 28 x 10^4 lbs./sec. A third stage consists of a solid-propellant rocket with a 1.1 x 10^4 lbs./sec. total impulse. This rocket carries a four-pound payload.

● **Such a combination of** rockets should reach a final burnout velocity of 37,500 feet per second, which is sufficient to propel the final stage and the payload to the earth-lunar gravitational neutral point. From this point the moon's own gravity will attract the last stage to the lunar surface at a terminal velocity of 7,920 feet per second.

Skyhook balloons of 3 x 10^6 cubic feet volume have been built and launched already. As a matter

Cross section—vehicle is approximately 35 feet in length. Rockets shown with high drag nose section.

of fact, small solid-propellant rockets have been carried aloft and launched from *Skyhook* balloons many times.

In the case of the lunar rocket, as proposed here, it might be necessary to employ a cluster of smaller balloons, rather than one big one. Of course, numerous launching difficulties must be encountered, whether one uses one big or several smaller balloons. Among the launching difficulties are such problems as keeping the vehicle stabilized under conditions of high winds. Shipboard-launching at a relative zero wind velocity may reduce such difficulties.

Wind loads on the balloon and suspended payload during ascent must also be considered.

At launching, the rocket boosters must point vertically, i.e. on the radius from the earth's center. To achieve this a suspension platform stabilized by gyro flywheels or small pitch and yaw rocket jets probably will be required. Engineering-wise this is no great task, since such stabilization platforms already are familiar to guided-missile engineers.

The Authors . . .

are introducing their private proposal for an extension of the plan presented in 1955 by Kurt R. Stehling and Raymond Missert for a balloon-launched orbital vehicle. Stehling, formerly with Bell Aircraft Corporation, is now Propulsion Head, Naval Research Laboratory. Richard Foster, ARS student-award winner, is a member of the NRL propulsion staff. The opinions are those of the authors and are not to be construed as official or as reflecting the views of the Navy Department.

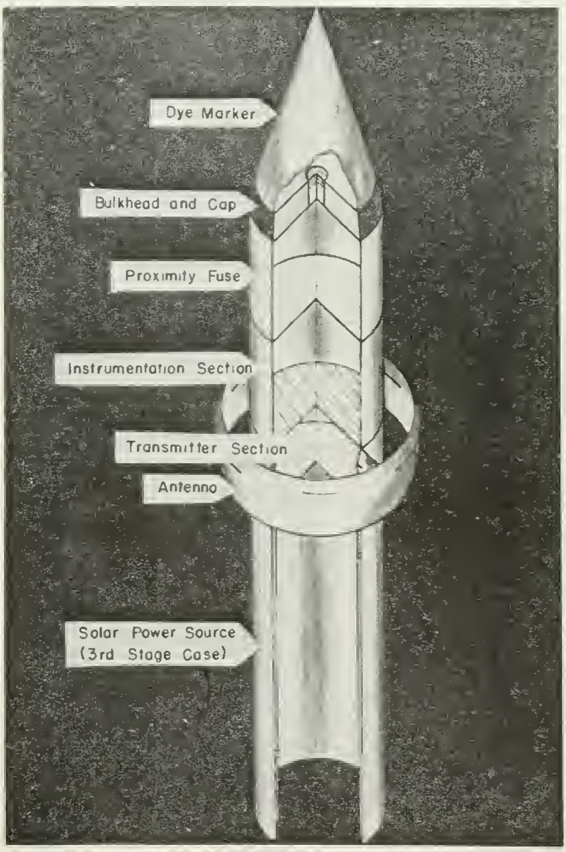
Rocket Zooms Through Balloon

An interesting aspect of this rocket configuration is that the whole vehicle, when launched by remote control from the surface, will zoom straight through the *Skyhook* balloon. The takeoff velocity is so great that the direction of firing will not be affected by the balloon. This method has been successfully demonstrated by the University of Iowa *Rockoon* experiments.

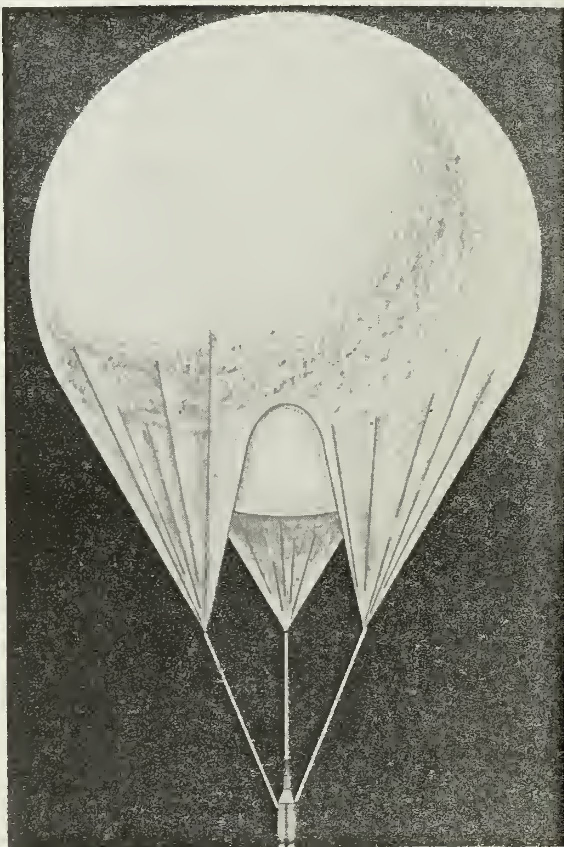
● **The three boosters** in the next stage will be manifolded together to minimize the initial overturning movement which normally results from unstable or non-simultaneous ignition, with subsequent uneven thrust development.

To stabilize the second and third stages of the launching vehicle, these rockets could be made to spin at some predetermined rate. This spinning creates so-called projectile stability. This principle is employed in the *Vanguard* satellite vehicle.

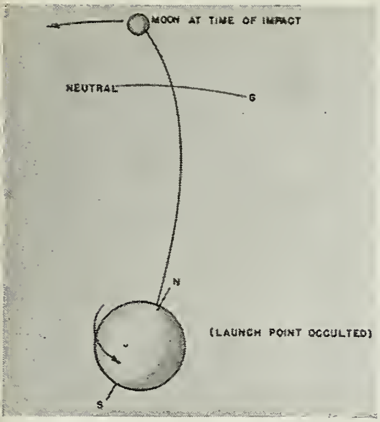
The coupling and release of large solid rockets is a formidable task. Since a high-altitude launch is presumed in this case, elaborate streamlining skirts and shields may not be necessary. As a matter of



Possible payload.



Suspension view.



Optimum impact trajectory.

fact, the second stage could nestle within or on top of the first-stage cluster, held only by the slip-joint of two concentric skirts. The exhaust jet of the second stage could issue through the triangular hollow column between the three first-stage boosters.

Similarly, the third stage could be ejected by gas pressure generated in the support structure which will provide rotational "hold," but no longitudinal "hold." This method would allow the third stage to spin with the second and yet permit separation at second-stage burnout. The gas pressure could be generated by a pyrotechnic squib in series with the third-stage igniter.

Ground command or a balloon-based timer could send the ignition signal for the first stage. Acceleration-sensitive switches could ignite the second and third stages on burnout of each respective carrier stage. A back-up system of long-burning fuses could also be used.

No provision is made for flight-path control of the last two stages. Other than the gyro stability of the spinning rockets, no electronic or other guidance is involved.

It is estimated that with a perfect launching and vertical flight path and a burnout velocity of 37,500 feet per second, the third stage—with its small payload—will hurtle toward the moon with sufficient accuracy to reach the neutral gravitational point.

● **The flight path** is influenced by the translational and rotational velocities of the earth. These are imparted to the radial velocity of the launching vehicle. The path is further influenced by the rather weak attraction of the sun and the stronger attraction of the moon.

If the velocity of the moon rocket's last stage at the gravitational neutral point between the earth and the moon is slightly greater than zero, the vehicle will actually reach a point of no return. A deficit or excess velocity at that point should result in either an earth or lunar orbit, a parabolic path around the moon and back to earth, or an impact upon the moon.

If the last stage returns to earth, it is possible that it will break up in the denser layers of the earth's atmosphere because of the great aerodynamic heating.

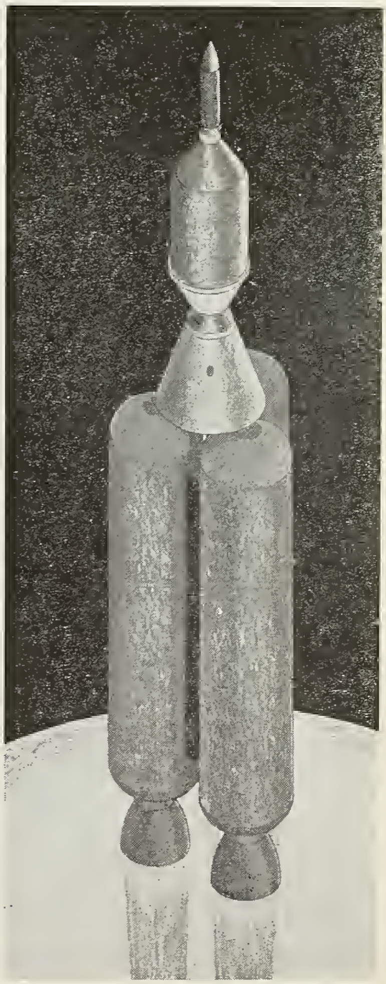
Mis-orientation of the vehicle at launching, thrust misalignment, unequal thrust levels and other instability factors will all determine dispersion and trajectory.

Landing on the Moon

It is difficult, within the limitations of this brief article, to specify the proper time and place for launching of this type of lunar rocket. It may be said, however, that time and place would have to be determined by the juxtaposition of the moon and the sun and the possible requirement of observation of the landing by stations on the earth.

If one assumes that the payload consists of nothing but a charge of metallic dust—such as magnesium—or a fluorescent powder, the impact or "landing" on the moon's surface may be observed as a large bright flash. It is assumed that the landing takes place on the darkened

Takeoff—vehicle shoots straight through balloon.



Solid-Propellant Moon Rocket Specifications

	Stage I	Stage II	Stage III
Gross Weight	26574 lbs.	1574 lbs.	64 lbs.
Structure Weight	200 lbs.	10 lbs.	0 lbs.
Payload Weight	1574 lbs.	64 lbs.	4 lbs.
Specific Impulse	245 sec.	245 sec.	245 sec.
Stage Mass Ratio	0.81	0.82	0.81
Firing Time	20 sec.	20 sec.	10 sec.
Peak Acceleration	42 g	40 g	91 g
Burnout Velocity	12,964 fps	13,474 fps	13,066 fps
Burnout Altitude*	180,000 ft.	280,000 ft.	352,000 ft.
Drag Velocity Loss	400 fps	0 fps	0 fps
Gravity Velocity Loss	644 fps	644 fps	322 fps
Thrust	236,000 lbs.	14,000 lbs.	1,100 lbs.

* *Assumes 70,000-ft. launching altitude*

Velocity Available	39,504 fps
Escape Requirement	—36,700 fps
Gravity Velocity Loss	— 1,610 fps
Drag Velocity Loss	— 400 fps
Excess	794 fps

surface of a segment of the "new" moon.

● **In all probability**, once a moon rocket with a four-pound payload capacity is available, the ingenuity of interested physicists and others will result in different kinds of "useful" payloads. Although metallic or a fluorescent powder would permit observation of the time and point of impact, which is important enough in itself, it is also feasible to design a more complex unit with a small one-function telemetering transmitter powered by solar "generators" or "batteries."

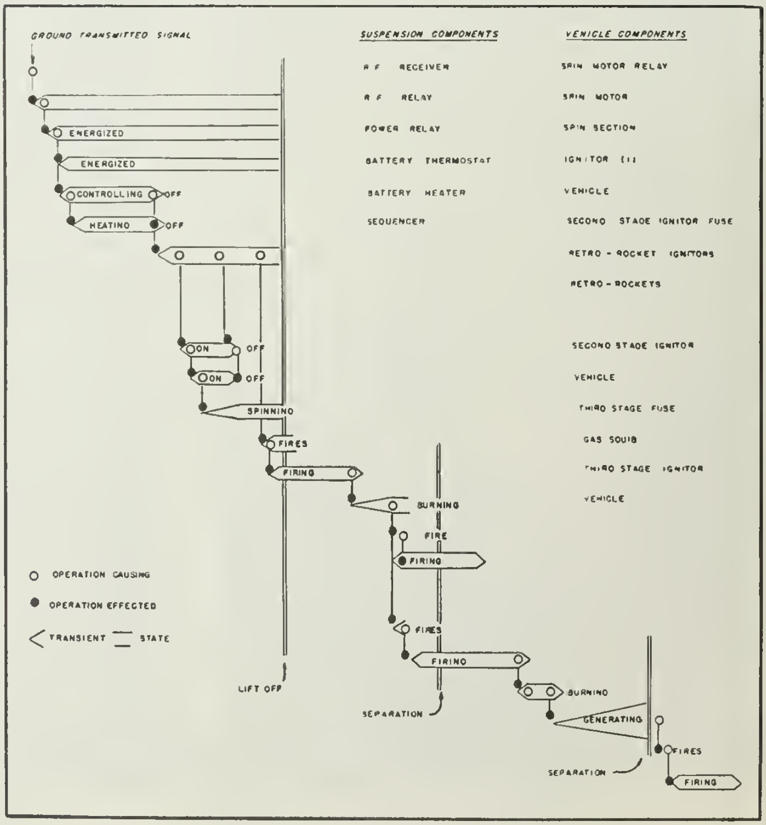
In the beginning such a transmitter could be active as a tracking and telemetering unit during the flight. It is, of course, questionable whether the reduced radiation efficiency of an antenna buried in or on the moon's surface would permit the reception of a readable signal on earth. Larger rockets employing a retro-thrust braking system during the descent to the moon probably could reduce the impact sufficiently to land a transmitter undamaged on the lunar surface.

Although the proposed lunar vehicle described here is rather simple in design and concept—and although the vehicle employs hardware, material and propellants which, considering unclassified information, may be readily available at a low cost—one should expect some "misfirings," or several launchings, to achieve one successful mission. First of all, the behavior of the rocket boosters is indeterminate because of intrinsic mechanical misalignment of the booster cases and their nozzles and the boosters with respect to themselves.

Furthermore, intricate design and split-second operational precision are requirements for the small retro-rockets that would be needed to retard the first stage and permit the spinning second stage to continue under its own momentum until this rocket unit is free and clear of the parent stage. However, the difficulties involved may not be greater than anticipated for many of today's missiles.

The success of a lunar rocket experiment, as outlined here, is a challenge to our engineers. It might well open up new vistas for science and help clear the path for further advancement in astronautics. END

First interplanetary body to be contacted from earth?



Flow chart of full firing sequence. Simplicity is apparent.

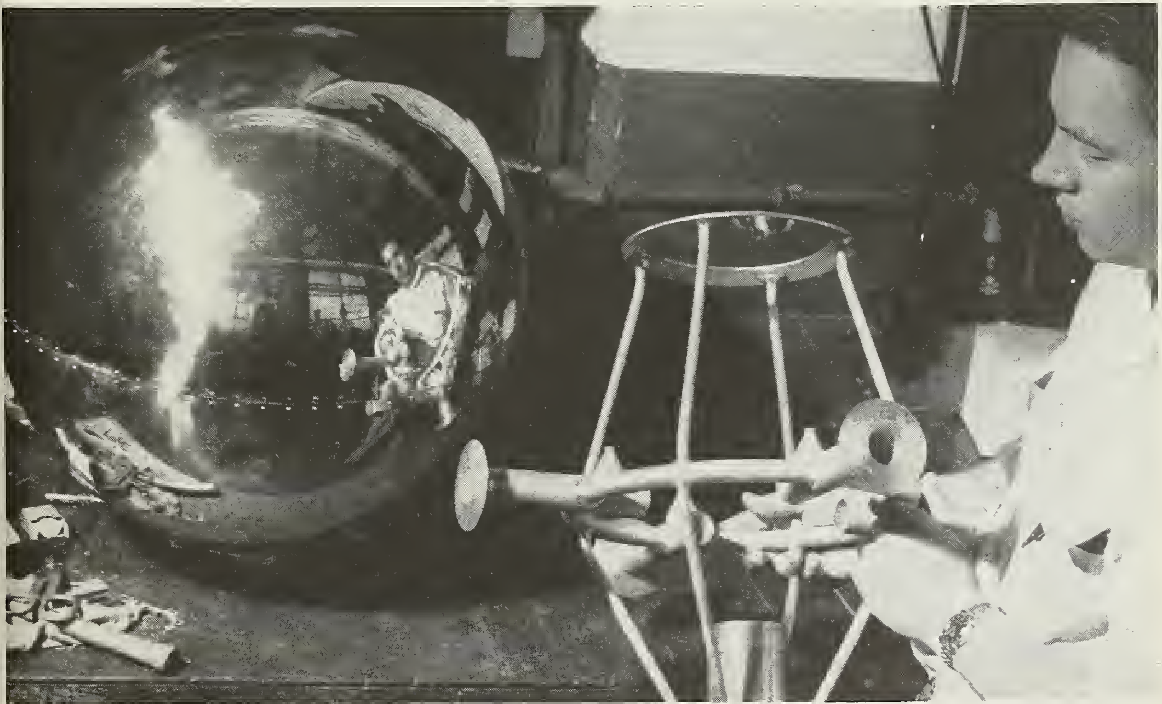
Hours of tedious work go into manufacture of hemispheres which are joined to form 20-inch Vanguard satellite. Sidney H. Braddy, NRL machinist, presses piece of sheet aluminum against large dome revolving in a fast-moving lathe. Metal is gradually worked closer to domed form to produce hemisphere.

First Pictures

BUILDING FIRST

What might well become the most significant scientific venture of our century, Project Vanguard, is reported to be progressing according to schedule.

The significance of the Vanguard satellite program is, of course, that our military agencies under the Department of Defense are working hand-in-hand with scientific organizations—and that



Robert H. Baumann, mechanical engineer, examines supporting structure and inner framework that will go into the satellite. The 29-year-old engineer has had many years' experience with rockets, having worked on Vikings, V-2s, Aerobees and others. He is currently Satellite Group Head under the Engineering Consultant for Project Vanguard.

THE SATELLITE

the scientific data obtained from the satellites will be made available to all countries.

MISSILES & ROCKETS will keep abreast of the Vanguard program as it progresses and keep its readers posted in every forthcoming issue. Much of the work pertaining to the launching vehicle is considered classified information, since many of the techniques employed are in

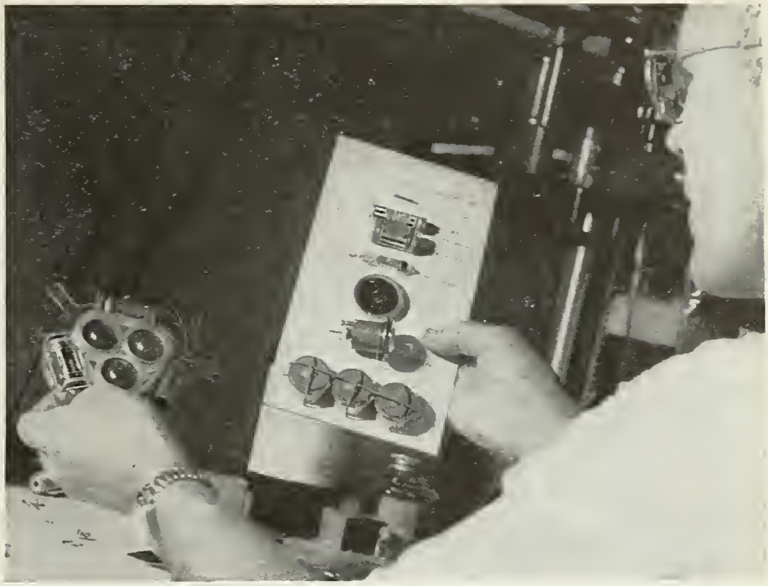
Joseph Y. Yuen, left, showing Vanguard Minitrack Transmitter to Erik Bergaust, Managing Editor of MISSILES & ROCKETS. Yuen, one of the developers of the tiny transmitter, points to circuitry.

Robert H. Peterson, 34, instrument maker, is shown putting in final screws to fasten together two hemispheres of test model satellite. Peterson started to work at the laboratory in 1945 and has had many years experience in field of guided missiles and rockets.

the area of missile technology. But the satellite itself and the experiments that will be attempted with it are unclassified. MISSILES & ROCKETS will publish as much information about these as possible.

It is too early to say when the first instrumented satellite will be launched.

N. Elliot Felt, operations manager of Project Vanguard for The Martin Co., disclosed that first firings in connection with the satellite program will take place at the Air Force Missile Test Center at Patrick AFB, Cocoa, Fla., this fall. His announcement was made at the recent International Astronautical Federation Congress in Rome. The first propulsion unit to be tested will be the third-stage solid rocket, which will be carried in a modified Martin *Viking* rocket.



E. T. Byram, NRL scientist, holds model of Lyman-Alpha equipment which is likely to form one of the experiments with the satellite. Byram compares components of Lyman-Alpha gear with assembly on the lucite wafer.

Project Vanguard scientists discuss design and performance of tiny transmitter which will send signal to ground from earth satellite. Joseph Y. Yuen and Martin J. Votaw discuss the relative merits of the various circuits and different components being tested for use in the Minitrack oscillator. At least 12 different experiments will be attempted with Vanguard satellites.

World Astronautics

By Heyward E. Canney, Jr.

The U.S. Air Force has officially stated it could use $39 million for earth satellite research. However, no money has been allocated for the next fiscal year.

Research at the Armour Foundation with heat and dust erosion suggests that much thicker meteor shields may be required for space vehicles. Copper and aluminum plates have been penetrated or badly pitted by particles travelling at 4,000 fps.

Last March 14 an Air Force Aerobee rocket discharged 20 pounds of compressed nitric oxide 60 miles above Holloman AFB. Catalytic action caused monatomic oxygen to recombine into conventional molecules. This action, which produced a disk four times the diameter of the moon, and at least half its brilliance, was confirmation of earlier laboratory experiments which lead to the suspicion that enough energy may be picked up in the ionosphere to power a rocket. If possible, this could lead to satelloids of indefinite duration.

This brings to mind the analagous proposition of a cosmic ramjet of the distant future whose main powerplant was replenished from cosmic dust taken in at enormous speeds. These, together with solar batteries, breeder reactors, and other devices, seem to be generating for the layman the optical illusion that science is on the verge of finding how to get something from nothing.

Pondering the globe-girdling aspect of the artificial satellite, the International Civil Aviation Organization, meeting in Caracas last June, decided that the matter of sovereignty of outer space above the several nations was within its competence. The term "outer space" may disturb the fastidious astronaut, who recalls the immensity of the universe. In the cosmic view, true "outer space" may be that between the galaxies, "middle space" that between stars of a galaxy, and "inner space" the realm within a system of planets, such as the Solar System.

A similar discrimination may be called for in the matter of man-made "moons." In this connection, accurate terminology may require some such distinction as the following: "artificial satellite"—any artifact in Keplerian orbit, "satellite vehicle"—any artificial satellite which carries a useful load (i.e. instruments), and "space station"— any artificial satellite offering a service on which other space vehicles (such as space ships) operationally depend.

Transistorized helmet radios designed for combat GIs by the Signal Corps have a one-mile range and are presumably hard for the enemy to intercept. Space suit designers may find this a convenience, and one less external component to upset balance, impede movement in cramped quarters, or to invite damage by bumping. RCA's new 19-lb. TV transmitter, which also has a one-mile range, may eventually find a place in the space man's practical equipment after a size reduction of one further order of magnitude.

Tracking the IGY Satellites

By Henry P. Steier

A very small and very simple assembly of electronics components will probably be history's reference point to mark the beginning of astrionics technology as a vital aid to man in his conquest of outer space.

Key to knowing whether the tremendous efforts of Vanguard rocket engineers have paid off will be wrapped up inside a little cylindrical, gold-plated aluminum can containing the circuit of a transistorized radio transmitter.

Minitrack transmitter. Circuit assembly in foreground. Batteries at right.

The sub-miniature transmitter is called the Minitrack. Designed by the Naval Research Laboratory, Minitrack will be the first electronics system to penetrate outer space and stay there for any appreciable time.

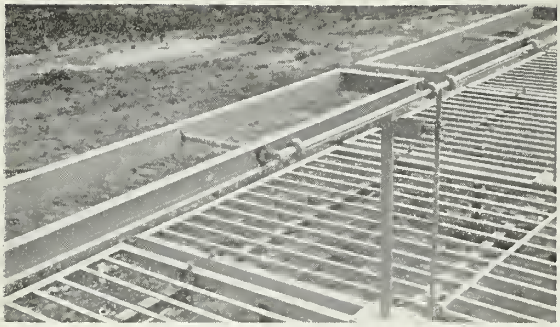
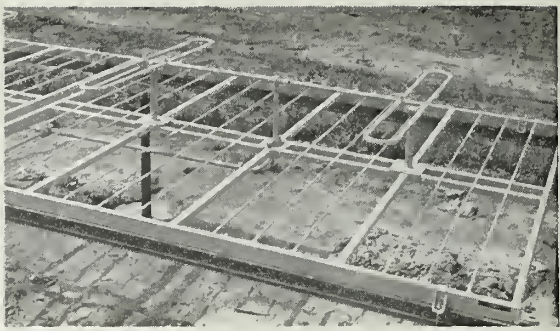
From inside its approximately five-inch-long by three-inch diameter cylinder housing, carried inside the magnesium shell satellite, Minitrack will emit a continuous 108-megacycle signal.

● **After nearly one orbit** is completed the world will begin to know if the satellite is in truth orbiting or whether something went wrong at the first *Vanguard* launching. After a few orbits, of course, the world will better know how well the satellite is orbiting.

Before the orbiting is finished and the magnesium shell is consumed by heat during its plunge to earth, scientists will have added a fund of important information to the limited store of information about the physics of outer space, as well as of the earth itself.

Use of radio in the satellite has two purposes. Once on its own, the shiny 21-inch sphere could get lost. Finding it has been compared to the problem of finding a golf ball traveling at Mach 1 at an altitude of 60,000 feet.

● **The first problem** is to acquire information on the satellite's location. After this is done, the next problem is to determine its

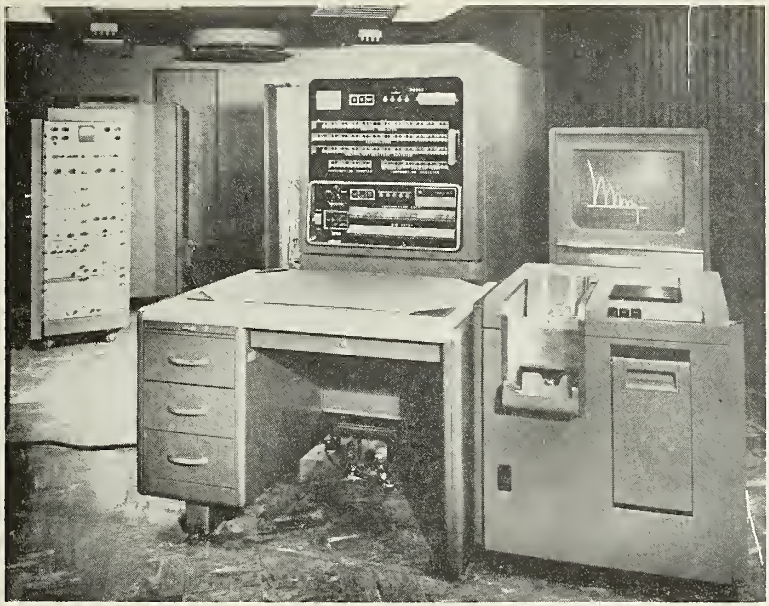
Details of prototype Minitrack ground station antenna arrays. Left: folded dipole array. Right: driven lot array.

ephemerides. By definition empheme-rides are the assigned places of a celestial body for regular intervals.

These are needed since two tracking methods will be employed to get the most accurate physical data from the satellite's performance. These are radio and optical tracking. The optical system, oddly enough, will be the most accurate. However, its use is feasible only when the sun position, satellite position and ground optical tracking system are in favorable relationship.

Under other conditions Minitrack ground stations will keep track of the satellite's whereabouts. During night, cloudy weather and under clear weather conditions, for a period of about three weeks, the signal will be available.

● **Despite all conjectures** on what the satellite will carry and how many different scientific readings it will take of conditions in its orbital path, there are still many uncertainties. What the first satellite will carry, will probably be a letdown to many. However, subsequent satellites undoubtedly will carry more and more instruments.



Dr. Paul Herget, Vanguard computation expert, says a cathode ray tube is planned for satellite data display. IBM's 704 Output Recorder was designed for use with a computer. Theoretical path of a bouncing ball is shown.

Although the possibility is still open for a zero-payload satellite, the probability that the first one will carry a Minitrack transmitter is good. At the present state of the electronics art, the transmitter weighs only 13 ounces. Carriage of this small payload seems feasible to rocket engineers.

Minitrack System

At this time Minitrack is a one-stage crystal-controlled oscillator designed to use one transistor and to be powered by seven 1.2-volt mercury batteries built by Mallory and Co., Inc. Power output would be 15 milliwatts. Transistors built by Western Electric Co. and the Philco Corp. are being considered.

A frequency of 108 mc was chosen as a compromise between transmitter weight and efficiency, and effects of the ionosphere on tracking accuracy. Although the ionized layer of gases at the proposed 300-mile altitude is essentially a "window" for radio energy at 108 mc, a certain amount of refraction is expected, just as with light through a glass window pane.

● **During the International Geophysical Year** the sun-spot cycle is expected to be at or near maximum. This means ionosphere activity will be at maximum and high electron densities are expected during daytime observations. This would cause an apparent shift in the angular position of the satellite when the signal is picked up by the ground stations.

Measurements on ionosphere errors to be expected have been made this year in *Rockoon* and *Rockaire* studies and will continue. More and more data will be collected pertaining to predictable and variable factors that would influence tracking errors. These could be used to correct readings from ground stations.

A lower frequency than 108 mc would mean more refraction and higher frequencies would mean less power from the transmitter for a given weight. The antenna system on the satellite is planned as a four-element array arranged in 90-degree steps around the sphere. The four 1/4-wave antennas would be folded and, upon release of the satellite, would spring into place.

The diminutive size of the Minitrack transmitter belies the vast and complex information acquiring, transmitting and data processing facilities it will set into operation.

To acquire the Minitrack signal a complex of ten prime Minitrack ground stations is under construction in the U.S. and South America. They are located over an area that stretches from Blossom Point, Md. to Santiago, Chile in a north-south direction and from San Diego, Calif. to Antigua Island, B.W.I. in a west-east direction.

Vanguard will be launched at an angle of 35 to 45 degrees to the equator in a southeasterly direction. During each orbit of the satellite the earth will have moved about 1600 equatorial miles to the east if the orbit requires an hour and a half.

● **The effect of** the earth movement means that the satellite's path will scan the areas where the stations are located. Stations are located at: Blossom Point, Md.; Fort Stewart, Ga.; Batista Field, Havana; Rio Hata, Panama; Mt. Cotopaxi, Quito, Ecuador; Ancon, Lima, Peru; Antofagasta, Chile; Peldehue Military Reservation, Santiago, Chile; Coolidge Field, Antigua; Naval Electronics Laboratory, San Diego, Calif.

Eight Antennas

Located at each station will be an array of eight antennas designed to measure the north-south and east-west angular position of the satellite as its signal illuminates them. They are arranged in the shape of a cross.

The antennas are multi-element arrays. Two types are being tested at the Blossom Point location. Prototypes have been developed by the Technical Appliance Corp. and the D. S. Kennedy Co. One uses a 12-element dipole array and the other an eight-element driven lot array.

Measurement of the satellite's angular position will be made by comparing the electrical phase of the signal arriving at one antenna of a pair compared to the phase at the second antenna of the pair.

● **Located at each station site** will be a complete Minitrack Electronic Unit mounted in an air conditioned trailer. Contractor for these units and other station units

is the Bendix Radio Division, Bendix Aviation Corp. It includes communication and telemetering equipment together with the Minitrack Electronic Unit phase comparison equipment.

The communication set includes 15-kw transmitters, receiving and transmitting rhombic antennas plus a telemetering antenna system and ground stations. Communication and telemetering units will be housed in a building which also contains office, parts, storage and sleeping facilities. Living arrangements for personnel will be obtained locally.

Telemetering equipment is being provided since although the first satellite may not include telemetering gear, subsequent satellites will.

Data Handling

At the "Fire!" signal for launching the *Vanguard* vehicle two auxiliary stations will go into operation. Located at the Air Force Missile Test Range on the islands of Mayaguana and Grand Turk in the Caribbean, these stations will receive signals from telemetering equipment in the vehicle and, after burnout, will receive signals from the satellite.

From these down-range stations will come the first information that tells of success or failure. The information will be radioed to a central *Vanguard* computing facility. Probably this will be located in Washington, D. C. From then on until the satellite falls to earth the computer and the Minitrack ground stations will operate on an around-the-clock basis.

Three bits of information from the Minitrack stations will be repeatedly sent to the computation center by radio and teletype. Two angular measurements and the precise time of passage over the zenith of the stations will be sent.

● The computer "brains" will do what men could not do—keep ahead of the satellite so that information on where the satellite *was* can be transformed into information on where it *will be*. This is needed to alert both the optical tracking stations and the Minitrack stations as to where the satellite is going to be at a specific time.

Optical stations, using 20-inch Schmidt photo-optical telescopes and equipped with automatic tracking gear, must know exactly where to look since the satellite will pass from west to east in two or three minutes. The stations will be operated under the direction of the Smithsonian Institute and will be located throughout the world where the satellite can be seen.

Dr. Paul Herget, consultant to the Naval Research Laboratory, will head the *Vanguard* computation facility. Back and forth, between it and between optical tracking stations and Minitrack stations, information will flow.

It will go from the center to the stations for alerting them as to satellite arrival time; from stations to the center to keep the computer up-to-date on changes in speed, altitude or direction.

● **Two classes of computations** are planned: in-flight calculations to aid and insure observations by optical means, and those from which scientific conclusions will be drawn.

Equations will be juggled to fit new conditions constantly occurring. More and more refined data will be accumulated, calculated and stored in the memory of the computer. When the end of the Minitrack transmitter battery life comes, the calculated data will still be available for alerting the optical stations for the next satellite passage and for the public to try to view the satellite.

Persons favorably located geographically during twilight and sunrise periods in good weather will be able to see the shiny ball with the aid of binoculars as it goes overhead.

Even if the satellite stays up much longer than the few weeks predicted, the available data, more refined after each satellite orbit, may be of a high enough order of accuracy to insure optical tracking for the entire satellite life. END.

NRL Planning Plug-in Satellite Instruments

During an interview with Missiles & Rockets, Dr. Herbert Friedman, who heads the Naval Research Laboratory's scientific instrumentation group for the IGY satellites, said the plan is to modularize astrionics according to a definite pattern.

In this way, by using the Minitrack transmitter as the radio frequency generator, various plug-in devices could be placed in different satellites to read different information scientists need. With appropriate coding and modulating techniques, the information could be relayed to earth through the Minitrack transmitter.

Many groups in the IGY endeavor want to "get on board" the satellite. Who will get on board and when is not definitely known. Advances must be made in micro-miniaturization, power sources, data storage and telemetering. Weight is extremely critical.

Who gets in first depends on the state of the instrument and electronics art, and many programs are under way in industry and at NRL to speed up this development.

Typical devices suggested are:

1. **Meteoric Collision Amplifier**—Signal from microphone detects collision with micrometeorites and provides input to meteoritic storage.
2. **Meteoritic Storage**—Magnetic cores form collision memory, store number of counts from collisions and transmit signals representing four decimal digits on four telemetering channels.
3. **Telemetry Coding System**—Successively samples various signal input channels and modulates the Minitrack for transmission of scientific data to earth.
4. **Lyman-alpha Storage** — Peak memory unit using cores to store and code the telemetering system with a signal representing maximum input value reached during one satellite orbit for subsequent read-out when passing over recording stations.
5. **Lyman-alpha Current Amplifier**—For measuring ionization produced by ultra-violet solar flare radiation.
6. **Ion Chamber-Narrowband**—For ultra-violet detection by having peak sensitivity at the hydrogen Lyman-alpha line.
7. **Thermistors**—A mixture of metallic oxides used for temperature measurements. Resistance changes with temperature.
8. **Erosion Gauge**—Nichrome ribbon evaporated on glass. Measures surface erosion caused by impact from micrometeorites. Resistance of ribbon increases as film is pitted.
9. **Solar Cell**—Peak memory reset for storage unit. Causes reset once each orbit on transition from light to darkness.

Government Holds 10% Of Electronics Patents

The Federal Government held more than 10% of the total of 3,130 electronics patents issued in 1955, according to an analysis by Information for Industry, Inc. The analysis shows that in the first six months of 1956, 3,084 U.S. electronic patents were issued, with a slight increase shown in the percentage assigned to the government.

Of the 321 government-held patents issued in 1955, 150 were issued to the Secretary of the Navy, 80 to the Atomic Energy Commission, 46 to the Secretary of the Army, 22 to the Secretary of War, 10 to the Secretary of the Air Force, 8 to the Secretary of Commerce, 2 to the Secretary of Interior, and one each to the Secretary of Agriculture, Reconstruction Finance Corp. and United States of America.

The largest number of patents have been issued to companies whose major endeavor is in the entertainment and appliance fields. These total 674, compared to 264 in wire communication, 220 in atomic energy, 151 in aircraft and guided missiles, 92 in petroleum, and 72 in business and office machines. The remainder were general patents.

Navy Seeks to Block Long Island Building

The Navy has asked the Senate and House Armed Services Committee for authorization to spend funds in buying land to discourage real estate development around the Navy-owned Grumman Aircraft Engineering Corp. plant and its adjoining airfield near Riverhead, L. I., N. Y.

To block residential construction, the Navy proposes to buy a small amount of land outright, and in other cases to pay landowners for two types of restrictions on the deeds to their property: restrictive convenants under which owners would agree to keep their land in its present agricultural use, and flight clearance easements that would limit the height of any buildings erected in landing and takeoff paths. Several thousand acres would be affected.

New 11,000 MPH ARDC Windtunnel

The Air Research and Development Command of the Air Force has disclosed that a blowdown windtunnel at Arnold Engineering and Development Center, Tullahoma, Tenn., has achieved simulated velocities up to 11,000 mph and temperatures up to 15,000°F on more than 100 successful test runs.

Known as "Hotshot," the hypersonic tunnel is capable of simulating the fantastic temperatures and velocities in store for the warhead of an intercontinental ballistic missile upon its re-entry into the atmosphere.

● So great is the heat produced by the tunnel, a part of ARDC's Gas Dynamics Facility, that portions of the tunnel ducting melt away during test runs, striking the models and interfering with test results. "However," the Air Force said, "this contamination develops later than it normally does in shock-tube tunnels, and is preceded by a longer, more uniform flow in which valid test data may be recorded."

Here is how Hotshot works:

Air is pumped into a storage chamber and sealed off from the downstream portion of the tunnel by a light plastic diaphragm. The downstream section is then pumped down to one-millionth of an atmosphere to accelerate the airflow when the seal is ruptured. At this point, a powerful electric charge of more than one million amperes is triggered into the air storage chamber, boosting the air temperature to 15,000°F and the air pressure to 20,000 psi.

The heated air immediately breaks through the plastic seal and flashes down the tunnel, accelerating as it moves through a conical nozzle in front of the model mounted in the test section. Instruments measure temperature, air flow and other details during the test, and photographs may be taken of the model in the luminous glow created by the super-heated, pressurized air blast.

Astrionics

By Henry P. Steier

ICBM tests will force astrionics engineers to brand-new concepts of telemetering accuracy. Dr. H. L. Rauch, University of Michigan missile telemetering scientist, points out that a 1 ft./sec. velocity error in a missile sent to a point one-quarter way around the earth would cause a target miss of about one mile. To measure such a slight velocity error, telemetering would need better than 1/100th of one percent accuracy, Rauch says. Accuracies of one to five percent are normal now.

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Lest anyone doubt what can happen in three years when scientists take over promotion and management and invade the field of big R&D business, a movie made by Ramo-Wooldridge Corp. and narrated by Dean E. Wooldridge, president and treasurer of R-W, shows the company offices in 1953. It is now a barbershop. In June 1956, R-W had 2,000 employees. By the end of 1956, it will have 600,000 square feet of R&D building space in Los Angeles on a 40-acre site. Under construction also is a manufacturing building facility in Denver, Colo. that will initially have 150,000 square feet on a 640-acre site.

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The same phenomenon may occur soon again. Aeronutronics Systems, Inc. was organized in 1956 as Systems Research Corp. Headed by scientists Dr. Ernest H. Krause, vice president, Dr. Montgomery H. Johnson, director of research, and Gerald J. Lynch, director of Ford Motor Co.'s office of defense products, Aeronutronics is now a subsidiary of the Ford Motor Co. From its present store-front headquarters in Van Nuys, Calif., the company is expanding to take over the former Glendale Airport terminal, which will house laboratories and offices for its work in aeronautics-nucleonics-electronics.

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Heat generated by astrionics equipment in satellites will be a major problem. With no means of transferring heat to the atmosphere under near vacuum conditions at satellite altitudes, heat would build up inside the satellites. Bendix Pacific Division, Bendix Aviation Corp. has taken a first step toward a solution with development of a water-evaporative heat dissipator. Heat from astrionics gear in a missile test vehicle raises temperature and pressure of water vapor in a sealed telemetering system. Water vapor is dumped overboard at 5 lbs./sq. in. absolute pressure.

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Latest approach to the problem of reducing friction in gyros to obtain more accuracy in inertial platforms is work toward a means of suspending the gyro in a vacuum by means of a magnetic field. Except for electrical contacts that might be required, such a gyro would have nearly infinite accuracy. At the same time, non-electrical gyros are being designed which are spun by pneumatic, spring-wound, or pyrotechnic means in a missile prior to firing. Ideal for small missiles since power supplies are not needed, and since they come up to speed in milliseconds, "self-energized" gyros are coming into the forefront. Electrical gyros sometimes take a full minute to come up to speed in the order of 10,000-20,000 rpm.

International News

By Anthony Vandyk

Four SNCA du Nord missiles are in operational service with the French forces—the 5201 (surface-to-surface), 5210 (air-to-surface), 5103 (air-to-air) and CT-10 (formerly designated 5501). The CT-10 is used as an anti-aircraft target.

The Royal Air Force will soon be equipped with its first missile—the Fairey *Fireflash*. It will be fitted to fighter aircraft within the next few months. Fairey is also working on a longer-range version of the *Fireflash*.

Bristol's *Thor* ramjet makes use of the cheapest and simplest methods of manufacture. It is strictly a missile unit with Mach 2 to 2.5 capabilities but it could easily be refined to give it a long life and thus make it suitable for powering aircraft. One Bristol official claims it would be more economical than a turbojet at Mach 3.

Napier's ramjet test vehicle, the NRJ.1, is not a missile but a plain "flying engine" for fuel control research, designed and built for Britain's National Gas Turbine Establishment. It is unique in having a diametric airfoil in the intake to generate its compression shock pattern. The NRJ.1 is about 20 ft. long and 18 in. in diameter.

British government's decision to declassify the Armstrong-Siddeley *Screamer* rocket engine indicates that the United Kingdom has abandoned LOX as an oxidant in favor of HTP—as used in De Haviland rocket motors. The current model of the *Screamer* delivers 9,500 lbs. thrust at 40,000 ft. It is a compactly-grouped motor 78 in. long, 28 in. in diameter and weighing 470 lbs.

For those who can read German the papers of the Deutsche Versuchsanstalt für Luftfahrt are available once again. The technical reports by the 44-year-old research establishment are now appearing regularly. They are published by Westdeutscher Verlag, Ophovenerstrasse 1, Opladen, West Germany.

How much does a missile cost? Colonel Franco Fiorio, formerly assistant Italian air attache in Washington, reckons about $150 per lb. for surface-to-air vehicles or $200 for air-to-air missiles. Fiorio is one of the foremost Italian Air Force experts on guided weapons.

Svenska Aeroplan (SAAB) is working hard in the missile field. The Swedish government's 1957-58 air budget includes $1,600,000 "for continued development of an interceptor missile." It is expected that the total cost of this project will be some $6 million. The major missile item in the budget is $28 million for the procurement of guided missiles for aircraft.

Russia has tested a 900-mile range ballistic weapon which was developed from Germany's V-2. Reliable sources indicate that between 1945 and 1950 the Russians built at least 2,000 V-2s.

France's SNECMA is the only manufacturer specializing in pulsejets. Its Ecrevisse series includes units ranging in thrust from 22 to 330 lbs. It is possible that the Ecrevisse will be built under license in Holland to power the Aviolanda target missile if the latter is ordered into production.

点は陸より「みくら」に連絡し，回収のためカッターを下したが，波打際の近くに落下したのでヘリコプターに回収を依頼し，ヘリコプターより鈎のある竿を出し海面すれすれの位置からパラシュートを鈎に引掛けてこれを回収した．ロケット・ボーン・カメラのフィルムは直ちに秋田市で現像し，6枚の空中写真撮影に成功したが分った．雲高が低かったため発射後すぐ雲に突入が，雲にはいるまでの間に撮影したものでき．

観測班：丸安班は開傘後これを捕え海面落 追跡できたが，発射後雲突入までは追跡できなかった．水野班は発射後雲に突入までを追跡，それ以後は発見できな

JAPANESE rocket research

By Frederick C. Durant, III

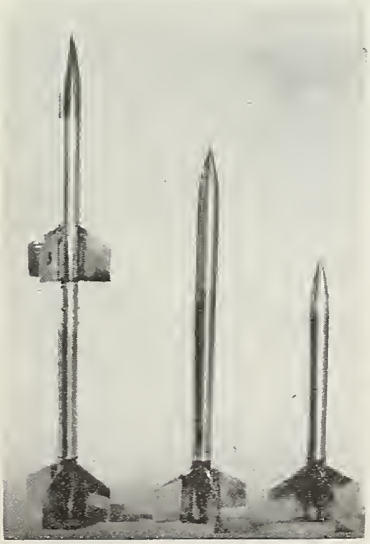
Two years ago there was no rocket research in Japan. Today, sounding rockets are being developed in an intensive, well coordinated program. Remarkable progress has been achieved in all phases on budgets which are miniscule by U.S. standards.

The program stemmed from the decision last year of the National Science Council of Japan to participate in upper atmosphere observations during the International Geophysical Year. In keeping with the times, the Japanese did not want their observations limited to research balloon altitudes. They decided to use sounding rockets. It was an ambitious decision since there had been no Japanese rocket development since World War II.

● Even during the war the Japanese had not made significant progress in rocketry. Developments were limited mainly to rocket artillery, solid-propellant JATO units and the Kamikaze BAKA bomb. The BAKA was a human-guided rocket-propelled flying bomb. Air-launched from Betty-type bombers at 25,000-27,000 feet, these suicidal attacks on U.S. Naval vessels were quite effective until adequate countermeasures were achieved. Liquid-propellant rocket development was apparently limited to development of a rocket powerplant for the Shusui airplane in the design stage in 1944-1945.

At the close of the war, of course, all rocket development stopped. None was permitted dur-


Baby rocket in launching rack.


Kappa rocket series.


Telemetering unit for Baby rocket.


Launching of Baby rocket.


Tracking and reception antennas.

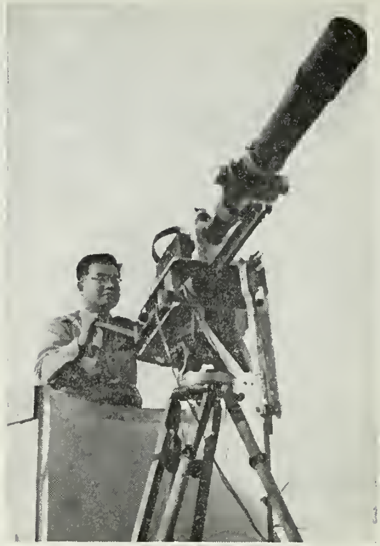


Photo-theodolite tracking rockets.

ing the period of U.S. occupation. Therefore nearly ten years elapsed before the opportunity arose for renewed effort on rockets, this time for purposes of scientific research. Throughout the post war period, however, Japanese physical scientists and engineers kept abreast of rocket developments in the rest of the world. Scientific journals and professional society reports reported significant data and test results as rocketry advanced to its present state of relative complexity. How well these advancements were absorbed, however, can be appreciated in the remarkable rate of development of the Japanese rocket program since last year.

A Special Committee for the Sounding Rocket Program was organized in January 1955. Research began in February. Budgeted funds were $140,000 for 1955 and $250,000 for 1956. Chief Scientist of this Special Committee was Dr. Hideo Itokawa, Professor of the Institute of Industrial Science, University of Tokyo.

● Dr. Itokawa was an ideal choice for this post. Forty-four years old, he received his aeronautical engineering degree from the University of Tokyo, and during the period 1935-1945 designed fighters at the Nakajima Aircraft Co. After the war Itokawa joined the staff of the University of Tokyo, received his Ph.D. at its Institute of Aeronautical Science and conducted theoretical research on aerodynamics, guided missile systems and target aircraft. His interests were far-ranging, carrying him into such ancillary fields as acoustics and medical engineering. Then the National Science Council tapped him to direct its sounding rocket program.

Supporting the development of rocket vehicles for the program was the Institute of Industrial Science, University of Tokyo. Aiding in related phases were:

1) Institute of Astronomy, University of Tokyo: Solar Radiation.

2) Kagaku-Kenkyusho Corp.: Cosmic Rays.

3) Department of Geophysics, University of Tokyo: Pressure.

4) Institute of Radio Wave, Department of Communication: Ionosphere.

5) Department of Electronics, University of Kyoto: Temperature and Winds.

A four-to-five-year plan was mapped out. Two preliminary programs, PENCIL and BABY, have been completed. During these tests, basic rocket design criteria evolved and telemetering range systems were developed. KAPPA, SIGMA and OMEGA projects will be the programs to obtain scientific data at high altitudes.

PENCIL Rocket Program

The PENCIL program was devised to obtain basic test data on rocket design elements. A miniature model was developed measuring 9 inches long, 0.7 inches diameter, weighing only half a pound, including the solid-propellant motor. Aerodynamic configuration, internal and external ballistic characteristics, motor and nozzle design were studied in a horizontal track test range 30-160 feet long. Completely but simply instrumented, in-flight photos were made by Fastax cameras. Velocity and dispersion data was obtained as the rocket passed through a series of six wired paper targets. Booster rocket length, tail-fin configuration, material of construction and other factors were studied to determine their effects upon center of gravity location and in-flight shift.

Of particular interest were ballistic characteristics of booster stages after separation. Because of the lack of deserted land for future large rocket tests, these data were necessary for range safety.

More than 150 PENCIL rockets

(*Continued on Page* 98)

The Author . . .

is a staff member of Arthur D. Little, Inc. Cambridge, Mass. He holds a degree in chemical engineering from Lehigh University. He is a past president of the American Rocket Society and of the International Astronautical Federation. He will be contributing a series of articles on international developments in forthcoming issue of M/R.

(*Continued From Page* 94)

were made and fired. The average cost of manufacture and test of a PENCIL rocket was $15.

BABY Rocket Program

With the basic design data obtained and experience gained in measuring techniques and test firings a larger rocket series was designed. Four to five feet long, not including a short booster rocket, this series weighed about 20 pounds. There were three major types: BABY-S (Simple), BABY-T (Telemetering) and the BABY-R (Recovery).

Initial test firing of Japan's first military rocket, the "TMA-O-AC" took place a few weeks ago at Ojoji proving grounds in northeast Japan. The rocket is a military version of one constructed for the Institute of Industrial Science by the Fuji Precision Machinery Co.

Officials of the Japanese Defense Agency who watched the rocket zoom to an altitude of 13,000 ft. termed the experiments successful. Other details were not immediately available, our correspondent in Japan said, but data gleaned from the trials is expected to pave the way for Japanese-built guided missiles.

Now the program moved out of the research laboratory into development phase. A launching site was selected in the north facing the Sea of Japan.

Six BABY-S rockets were fired in August 1955, only seven months after the initiation of the basic studies. These firings checked the launching stability and dispersion of this larger test design. In addition, equipment was developed for optical and DOVAP tracking, a launching tower constructed and range crews trained.

In September, six BABY-Ts were fired to study the fundamentals of rocket telemetering systems. Rocket-borne instrumentation was designed and tested. Four channels were commutated—velocity, acceleration, pressure and temperature—on 415 MC frequency.

During the next two months the BABY-Rs were launched. Since no land-firing ranges exist in Japan, it was recognized that recovery of non-telemetered flight data would have to be made from the sea. An ingenious but simple parachute and self-inflating buoy system was packed into the nose to be explosive-separated after maximum altitude was reached. A dye type sea marker completed the recovery unit. A 16mm camera and film was used as payload in these early shoots. Range firing trajectory data was radioed to the aircraft, helicopter and coast guard ship recovery unit. Two out of the three payloads were successfully located.

● **The Kappa Project** phase of the sounding rocket program is currently under development. Designed for the IGY program upper atmosphere measurements, this series of rockets will be three-staged, ground-launched and powered by solid-propellant motors. Length, less two booster stages, is 6.5 feet; diameter, 5 inches; weight, 80 pounds. It is designed to carry 11 pounds of payload to an altitude of 70-95 miles. Only one measurement will be made with each firing.

● **The SIGMA Project,** a rockoon system, utilizes a balloon for altitude launch. Basic studies and test data of Dr. James A. Van Allen of the University of Iowa are used in this project. Either the KAPPA main stage or a two-staged BABY rocket will be used. Design altitude: 50-65 miles.

● **Still in the study stage,** the OMEGA Project is aimed at altitudes over 150 miles. It probably will not be completed in time for the IGY.

To anyone familiar with the cost of overall sounding rocket programs in the U.S. the success of this program will be impressive. True, the Japanese had the benefit of much published data on the test programs of other countries. However, their work was not imitative. They have shown that they understand the basic factors involved as well as laboratory and field techniques. Further, they have recognized the present and future capabilities of solid-propellant rocket systems. END.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

BORON BUSINESS BOOM

In screen-testing today's array of miracle chemicals and wonder metals for roles in the billion-dollar guided missiles program, one old, but current big-time, performer should command much attention on the part of the investor. This candidate is boron—an element which, along with sodium and oxygen, gives us borax, the long-time cleaning companion of housekeepers everywhere.

Last year boron production hit a peak of nearly one million tons—three times the 1945 output—and recent estimates placed domestic and export sales in excess of $30 million annually. Broken down among end uses, boron consumption is as follows:

Industry	Type of Use	Estimated % of Total
Glass	Borosilicate Glass & Glass Fibers	30
Ceramics	Ceramic Glazes & Porcelain Enamel	25
Agricultural Chemicals	Fertilizers and Herbicides	15
Soap	Soaps & Cleaning Compounds	10
All Other	Flameproofing Agents, Adhesives, Gasoline Additives, etc.	20
		100

As these products (glass fibers, for instance) find new applications, they in turn will provide a still greater base for boron demand.

New Uses

Remarkable hardness and resistance to heat and corrosion places boron steel and other boron alloys in demand for jet engines and rockets. The fact that $100 million has been allotted for procurement, research and development of non-ferrous metals and alloys during 1957 gives an impressive indication of what is in store for metals that meet the desired specifications.

In addition, the 1957 defense budget for guided missiles earmarks another $70 million to the development of high energy propellants. Research indicates that since 1952 experiments involving boron compounds have progressed from the laboratory, through pilot-plant stage and are now in the tonnage-plant stage.

Although information on these projects is classified, there have been some significant and foretelling developments. For instance, the Navy recently announced the awarding of a $38-million contract for a plant at Muskogee, Okla.; Olin-Mathieson Chemical revealed a contract to build a $36-million plant near Niagara Falls; Stauffer Chemical recently embarked on a proposed ten-fold expansion of its Niagara Falls boron trichloride plant; and it is rumored that American Potash is starting up a semi-commercial plant in Los Angeles to make boron trichloride.

Informed opinion is satisfied all these operations embrace boron compounds to make high-energy fuels. And it is already known that

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Swift Carries Fireflash

Vickers-Supermarine *Swift* MK7 supersonic fighter, fitted here with two Fairey *Fireflash* air-to-air guided missiles, was unveiled at recent SBAC Farnborough exhibition. It is the second British fighter to mount *Fireflash*, the other being the Hawker *Hunter*.

Fireflash is a supersonic air-to-air missile measuring 90 inches in length with cruciform wings of 28-inch span. It is powered by solid-propellant rockets and warhead is proximity-fused to explode when missile is within lethal range of target.

Guidance for the missile is a beam-rider type system. Electronic equipment was developed by E. K. Cole, Ltd.

First production order for the *Fireflash* was awarded to Fairey early this year and deliveries to Royal Air Force Fighter Command are due within the next five months. Fairey is one of the forerunners of some 150 British firms engaged in missile work, with most activity in the air-to-air and surface-to-air categories.

Army Rocket Sled Attains 1,300-MPH

This new rocket sled, built under Army direction by Aircraft Armaments, Inc. reached speed of 1,300 mph during recent tests at Naval Ordnance Test Station, Inyokern, Calif. The 7,000-pound sled, powered by three solid-propellant rockets, reached this velocity in less than 2.5 seconds. This particular test vehicle was designed for the Army for testing operation of aircraft and missile components at high speed. Aircraft Armaments, a Baltimore firm, is understood to be planning to better the 1,300-mph mark, presumably with an advanced sled design, as part of an overall rocket test vehicle development program.

(*BORON cont. from p.* 100)
boron polymers, such as pentaborane and decaborane, have a high energy content and desirable physical properties.

Another amazing discovery is the fact that boron hydrides and boron hydride derivatives react violently with water, and offer possibilities as fuels for underwater rockets.

Investment Possibilities

It seems almost certain that the boron industry offers intermediate and long-term possibilities for extraordinary capital appreciation. Buttressed by currently expanding uses, boron's potential seems virtually unbounded in the added area of jet-rocket requirements.

About 90% of the world's boron production is in the United States. Not too many companies participate in this output; however, the following companies are available for consideration by the investor:

	Percentage of Total U.S. Production	Recent Price Aug. 15, 1956	Where Traded*
Operating Co.			
U.S. Borax & Chemical	66	48	O/C
American Potash & Chemical	26	49	NYSE
Stauffer	8	75	NYSE
Holding Co.			
Borax Holdings, Ltd.	†	39	LSE

* O/C—Over the Counter.
NYSE—New York Stock Exchange.
LSE—London Stock Exchange.
† Owns 74% of U.S. Borax plus more than 15% of the remaining world supply of boron.

U.S. Borax & Chemical—the amalgamation of Pacific Coast Borax and U.S. Potash produces two-thirds of our domestic output and owns approximately 60% of the world's boron supply. It is said to have more than a 200-year supply of reserves.

$4.2 Million Contract To Douglas

DOUGLAS AIRCRAFT CO. Santa Monica, Div. has received a $4,279,692 Air Force contract for air-to-air rockets, presumably in *Sparrow* series.

Minneapolis-Honeywell To Build Fla. Plant

A new $4-million aeronautical plant for development and production of highly advanced aerial navigation equipment will be built by Minneapolis-Honeywell Regulator Co. near St. Petersburg, Fla. The new plant will provide 207,500 sq. ft. of floor space on a 95-acre site.

About 1,500 engineers and skilled workers will be employed when full-scale production of the inertial guidance systems begins, probably by the middle of 1957. Construction of the firm's first Florida facility will be started immediately.

Paul B. Wishart, president, said the company's decision to build a major new plant was prompted by extra government contracts and Honeywell's plans for expanded activity in the inertial guidance field.

Convair Awards Contract For $40-Million Plant

Convair Division of General Dynamics has awarded a general contract to McNeil Construction Co. of Los Angeles to build its new $40-million Astronautics facility for *Atlas* intercontinental ballistic missile development.

Plant site is a 252-acre plot northeast of San Diego. Partial occupancy is expected by next spring.

The Astronautics facility will provide nearly 1,000,000 sq. ft. of floor space. It will consist of a one-story, high-bay manufacturing plant of about 500,000 sq. ft., two six-story office buildings for administrative and engineering staffs, a 147,000-sq. ft. engineering laboratory, a cafeteria-auditorium, an instrument and computing center, plus other special-purpose buildings.

Raymond Rosen Firm Now Tele-Dynamics, Inc.

Raymond Rosen Engineering Products, Inc., producer of telemetering equipment for such missiles as the *Nike*, *Terrier*, *Matador* and *Firebee*, has changed its corporate name to Tele-Dynamics, Inc. with headquarters in Philadelphia.

The new firm remains a wholly-owned subsidiary of Raymond Rosen and Co., Inc. and will retain a west coast office in Sherman Oaks, Calif.

Industry Well Represented At Venice AGARD Meeting

U.S. companies were heavily represented at the four-day Guided Missiles Conference which ended last Thursday in Venice, Italy. Of the 23 papers presented at the meeting, about half came from American engineers and scientists.

The unclassified meeting was sponsored by the Advisory Group for Aeronautical Research and Development (AGARD) of NATO. Its principal theme was missile guidance, and the papers covered virtually the entire field of guidance problems.

Weapons system philosophy and guidance techniques were the principal subjects covered on the first day of the meeting, Monday, Sept. 24. Papers presented on Tuesday discussed use of digital computers, problems of gyro-stabilized servo platforms, inertial guidance and linear homing navigation. Missile instrumentation, field testing and reliability were covered on Wednesday, while Thursday was devoted to papers on the pitfalls of missile control, effects of airframe characteristics on guidance, flight evaluation of guidance components and new principles of missile guidance.

Reeves Instrument Has Five Major Projects

Recent disclosure of the $10-million development and production by Reeves Instrument Corp. of the world's largest chain radar tracking system at USAF's Patrick AFB missile range brings to five the number of major projects tackled by the Dynamics Corp. of America subsidiary.

Earlier it contracted to build a million-dollar electronic test and flight simulation laboratory at the AF's Wright Air Development Center for research on aircraft and missile design problems.

In its own project "Cyclone" computer, built for Navy Bureau of Aeronautics in 1946, it reportedly has solved for as little as $50,000 a design problem that would have cost $100 million in a comparable flight test program.

New NACA Employment Program For Military Scientific Personnel

National Advisory Committee for Aeronautics, hard-pressed earlier this year by the threat of a mass loss of scientists to private industry, has found a new answer to its employment problem.

Under a cooperative NACA-Pentagon venture, Defense Department is making available to NACA qualified military personnel for assignment to scientific research projects. About fifty officers from the Army, Navy and Air Force are expected to enter the program by early next year.

The move has two-fold benefits, NACA says. It not only supplies it with hard-to-get technical and scientific talent, but also provides active-duty scientific training for a select group of military personnel.

As a result, various military departments are supplying NACA with volunteer lists of volunteer eligible officers from which it may select candidates. They are expected to be assigned to NACA research activities dealing with military's long-range plans for aircraft, missiles and rockets.

Here's how individual services are handling the program:

Army—Provides NACA with names of ROTC graduates who will be offered 18 months active duty with NACA after completing six-month duty in Army training.

Navy—Will submit list of qualified officers with aeronautical engineering degrees who have two years additional obligated service, or who indicate desire to extend their tour of duty to accept NACA assignment.

Air Force—Provides NACA with list of officers who volunteer for two-year NACA duty.

In each instance, officers assigned to the program will, for all purposes, be NACA employes. Pay, allowances and other costs will be reimbursed to the particular service.

The Defense step is the most recent of a number of moves aimed at relieving NACA's scientific personnel problem.

Earlier, in a session-ending measure, Congress authorized NACA 20 additional "Public Law 313" jobs. Although NACA had asked for 50 such positions, the 20 voted by Congress gives it 30 jobs in the $12,500 to $19,000 a year category.

Added to this, most widespread improvement throughout NACA's organization stemmed from action by the Civil Service Commission in late August. This authorized NACA to pay top-of-grade salaries to some 1,625 NACA research scientists effective September 25.

As a result of this last measure, here's how the new grades now pay within NACA: GS-9—$6,250; GS-11—$7,465; GS-12—$8,645; GS-13—$10,065; GS-14—$11,395; GS-15—$12,690; GS-16—$13,760; and, GS-17—$14,835.

CALENDAR

OCTOBER

1-3—National Electronics Conference and Exhibition, sponsored by AIEE, IRE, Illinois Institute of Technology, Northwestern University and University of Illinois, Hotel Sherman, Chicago.

1-3—Canadian IRE Convention and Exposition, Automotive Building, Exhibition Park, Toronto.

2-6—National Aeronautical Meeting, Aircraft Production Forum and Engineering Display, sponsored by SAE, Hotel Statler, Los Angeles.

8-10—Second Annual Symposium on Aeronautical Communications, sponsored by IRE, Hotel Utica, Utica, N. Y.

10-12—National Transportation Meeting, sponsored by SAE, Hotel New Yorker, New York City.

10-12-16—NACA triennial inspection of Langley Aeronautical Laboratory, Langley, Va.

15-19—Second annual world-wide conference of USAF Flying Safety Officers, Keesler AFB, Biloxi, Miss.

15-17—Fall radio meeting of Radio-Electronics-Television Manufacturers Assn., Hotel Syracuse, Syracuse, N. Y.

16-19—Conference on Magnetism and Magnetic Materials, sponsored by IRE, AIEE, APS and AIMMEE, Hotel Statler, Boston.

22-23—Radio Technical Commission for Aeronautics fall meeting, Hotel Marrott and CAA Technical Development Center, Indianapolis.

25-26—Aircraft Electrical Society annual display of electrical equipment, Pan-Pacific Auditorium, Los Angeles.

29-30—Third Annual East Coast Conference on Aeronautical and Navigational Electronics, sponsored by IRE, 5th Regiment Armory, Baltimore, Md.

NOVEMBER

8-9—National Fuels and Lubricants Meeting, sponsored by SAE, Mayo Hotel, Tulsa, Okla.

25-30—American Rocket Society annual meeting, Henry Hudson Hotel, New York City.

28-30—First International Congress on Ozone, sponsored by Armour Research Foundation, Sheraton Hotel, Chicago.

JANUARY

28-31—Eighth Annual Plant Maintenance Show, Public Auditorium, Cleveland.

New Communications *Concept*

for exchange of information amoung missile engineers

By Arthur W. Steinfeldt

In the midst of an explosive growth, communications within the missile industry have not been able to keep pace with the rapid technical advances and specialization. Due to the interdependence of missile technologies, progress in one area must be quickly communicated and integrated into the programs of other technologies. However, the missile industry is finding it increasingly difficult to digest and assimilate the specialized knowledge pouring forth from scientists and engineers drawn from diverse and esoteric fields.

Sources of basic, unclassified information are widely scattered geographically and the dissemination of material is often in a random, haphazard fashion. This is further complicated by the fact that most of the established periodicals, scientific journals and societies are directed either toward one small segment of missile technology, or are so general as to include the entire aviation industry.

The establishment of the Missiles & Rockets *magazine by American Aviation Publications is further recognition and response to the need for better means of communication in this rapidly maturing industry, and I am pleased to write for this first issue of the magazine concerning the initiation of an experiment in technical communications undertaken by the Special Defense Projects Department of the General Electric Company.—A. W. S.*

It is apparent that engineers and scientists in the missile industry must know not only their own field but should be aware of the knowledge, contributions and problems of other related technologies in order to make a maximum contribution themselves. This is especially true in an industry where technology is expanding rapidly. Long-standing demarcation boundaries between sciences are being rapidly changed and modified and entire new sciences are being born.

It has been obvious that there is a need for a program (1) to facilitate the flow of current information among engineers and scientists in the missile industry, (2) to provide knowledge as to where related technical work is being conducted, (3) to show how diverse technical fields are related and integrated in the missile industry, and (4) to stimulate engineers and scientists into thinking more about the relationship of their effort to other technical fields and common missile problems.

General Electric's Special Defense Projects Department decided to attack these problems on a modest basis by undertaking a series of *technical forums*. Four forums were planned as a series, each one in a different city with new speakers and a new program. The forums were announced in newspapers and tickets sent to qualified engineers and scientists. Over 1,000 attended the series.

● There were a number of practical considerations which led us to organize the forums as outlined above. GE wished to make attendance at the forum as convenient as possible and appeal to a wide range of engineers and scientists. To do this, it was necessary to bring the forum to them in the localities where they worked and lived. GE felt this approach would enable many persons to attend who would not have the opportunity otherwise. This required that the forums be unclassified and, of course, this brought the question of security to the forefront.

How often when discussing the national security aspects of missile work has one heard phrases such as, "Everything interesting in the missile field is classified," or "I wish the security people would declassify some of my work so I could prepare it for publication." I believe this sentiment is quite common and deserves more thought. Scores of worthwhile articles related to missile work are being published each month in unclassified journals. Many more would be available but are not because of

individual inertia rather than security limitations.

Security Problem

Security people are fully aware of the necessity for exchanging scientific and technical information where no classified material is involved. GE found them most helpful and cooperative in clearing talks for presentation and publication. It takes time and effort to accomplish this, but our experience has shown that it can be done and that most of the effort need not consume the time of our professional technical people.

● **To meet our objectives,** it was necessary that the presentations be of high caliber and of interest to an audience differing widely in background. It was decided that rather than have our speakers deliver a highly specialized talk, each would attempt a technical presentation of interest to the entire audience. This was not entirely possible but most of each presentation was understood by the audience generally. Sufficient time was scheduled to permit detailed discussion of the subjects for those who wanted to explore them in depth.

In order to overcome some of the barriers between various sciences, the technical forums were organized to present a number of papers from diverse fields. This diversification can best be illustrated by the subjects that were treated at the various technical forums by the speakers who were selected from the Special Defense Projects Department.

At the first forum held in New York City, Systems Engineering, Hypersonic Experimentation and Mass Accelerators and Aerophysics were discussed. At the second forum in Buffalo, our speakers treated the subjects of Missile System Testing, Aerophysics and Stress Analysis. The third forum in Washington. D. C., covered Structures, Aerophysics, and Recording and Recovery of Missile Data. The fourth and last forum of the series in Boston discussed Missile Reliability, Instrumentation and Hypersonic Experimentation.

Numerous visual aids, including colored slides, models and mock-ups, were used to further in-

terest the audience and stimulate discussion. Each presentation was limited to 30 minutes in length and a discussion period was allowed after each talk. A general discussion period followed the last speaker.

● **Each person** attending the forum was asked to fill out a brief questionnaire. This was done to measure the effectiveness of the forum and to obtain suggestions for improving future forums. A very high return, approximately 65% of the questionnaires per forum, was obtained.

Here are the conclusions based upon the reaction of the engineers and scientists who attended our first series of forums:

1) There was almost unanimity of agreement (97%) that the forums were worthwhile and that those attending would attend future forums if they were offered the opportunity.

2) Those in attendance felt that the information offered was current and of interest to them.

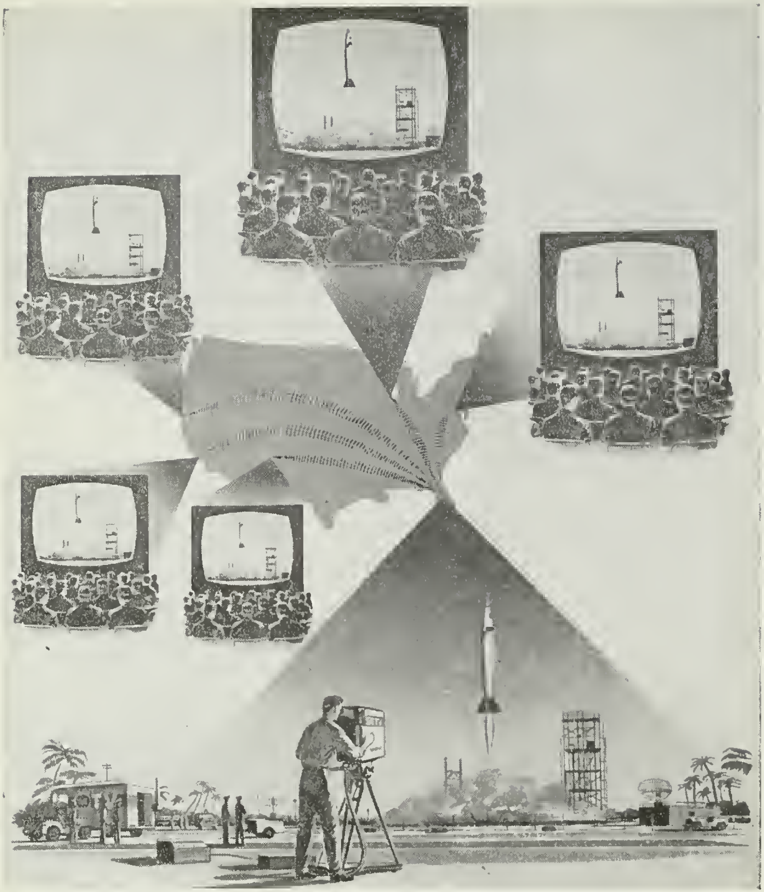
3) A substantial portion of the audience was quite amazed how closely seemingly diverse fields were related and integrated. They felt they obtained valuable information from presentations made by specialists in fields they normally considered outside of their particular sphere of activity.

4) They obtained considerable information from both the speakers and others in attendance about where technical work was being conducted of which they had no prior knowledge.

5) In indicating what fields should be discussed at future forums, the audience indicated that they would like to continue to have covered more than just their own technical field if they continued to be handled properly.

Tremendous Potential

As part of the forum program, our marketing organization scheduled press conferences where our participants matched wits with both the technical and non-technical press. This they found especi-



Nationwide closed circuit television would permit scientists to be "present" at important events and thus get firsthand information.

ally stimulating. In two cities they were asked to appear on television. Several of the presentations have already been published in technical journals and others are slated for future publication. Our marketing people were also pleased with the favorable publicity that was obtained in the daily newspapers and in non-technical and technical magazines.

● GE has come to realize that industry-sponsored efforts in technical communications have tremendous potential and it is a function which can no longer be left to chance. The missile industry has a direct interest and responsibility for doing its part in filling the communications' void resulting from ever increasing specialization and rapid technological advances.

A number of techniques could be employed. I would like to offer one for consideration. A series of technical forums could be planned on an industry-wide basis. Each industrial organization involved would schedule technical forums of its own in the local area. Engineers and scientists in the surrounding area who are interested in missiles, or already engaged in the field would be invited to attend. Then, to tie the entire effort together, a closed-circuit television program could be developed. Each company would select one or two subjects for presentation on the industry hook-up. The TV broadcast would originate from laboratories or missile proving grounds throughout the country. In a matter of minutes, each person attending would be tuned in on the latest scientific developments.

Imagine the inspiration and clash of ideas that could result from researchers all over the country actually watching—in a sense participating—while the nation's leading scientists demonstrate a problem or experiment. Exposing ideas to the fierce glare of the television camera and to hundreds of scientists in the field would be the quickest way I know of to separate out good ideas from the bad.

The forum idea could also be expanded to help the missile industry in the tremendous training job that has to be done. Each year thousands of engineers and scientists are brought into the industry and must be quickly integrated. Much of the orientation and training they receive is of an unclassified nature. Why not use closed circuit television to bring the best speakers from industry, government and universities to conduct appropriate sessions with a nationwide audience?

I have mentioned only a few applications of the use of industry forums and closed circuit television to improve communications. Actually the possibilities seem almost limitless. . . . END.

NAA Employs 500 In Summer Program

More than 500 students and faculty members from colleges and universities throughout the country have been on North American Aviation's summer payroll this year as part of the manufacturer's new long-range recruiting program. Breakdown of this temporary employment is as follows: Los Angeles division, 249; Rocketdyne, 115; Autonetics, 69; Missile Development, 66; Atomics International, 17.

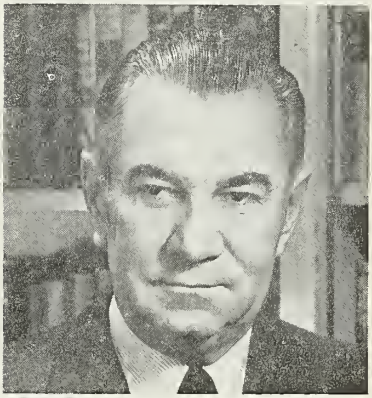
Mac Wright, coordinator for the program at Los Angeles, said the wide-scale summer work program was helpful to NAA in various fields and at the same time gave potential employes a chance to get to know the company. Hiring of faculty personnel, he said, is good for both teachers and the company in giving teachers practical experience in the application of their academic courses.

Technical Employee Increase

LOCKHEED AIRCRAFT CORP. estimates that one person in every eight it now employs is a technical employee. In 1943 only about one in every 100 was a technician or engineer.

PEOPLE

Lawrence D. Bell, president of Bell Aircraft Corp. since he formed the company in 1935, has resigned for reasons of health. He has been elected

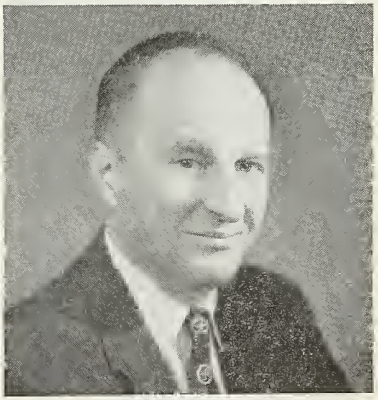


Lawrence D. Bell

chairman of the board. One of the few surviving pioneers of the industry era prior to World War I, 45 of his 62 years have been spent in aviation. **Leston P. Faneuf** will succeed him as president and will continue as general manager of the company.

Alexander Satin, well-known research engineer, has been appointed Senior Scientific Advisor to Lockheed Aircraft Corp., Burbank, Calif.

Formerly Chief Engineer of the Air Branch, Office of Naval Research in Washington, D. C., Satin



Alexander Satin

was recently presented with the Meritorious Civilian Service Award for his "outstanding leadership in initiating and coordinating a comprehensive research program in aerodynamics, structures, powerplants, instruments, experimental airplane, helicopters and other techniques and equipment used in naval air warfare."

Satin has been credited with the initiation of several scientific Navy and Army research projects, including rocket devices, short-takeoff-and-landing aircraft experiments, jet-lift and ducted fan propulsion and satellite research.

Marvin B. Ruffin, vice president-customer relations since April 1955, has been promoted to vice president and gen. mgr. of Summers Gyroscope Co.

Republic Aviation Corp. has named **Robert W. Boesel** chief project engineer for its guided missiles division.

Boesel

Ruffin

Daniel A. McBride and **Eugene L. Olcott** have joined the Chemistry Division of Atlantic Research Corp., Alexandria, Va., McBride as project coordinator and Olcott as metallurgical engineer. **Dr. Joseph B. Levy** will conduct research on the kinetics of solid-propellant combustion and of high-temperature gaseous reactions.

Clare W. Harris has been appointed a project engineer for Lockheed Missile Systems Division, while continuing to serve as asst. to the director of engineering; **Harry W. Kohl** was named division engineer for the newly created Bay area project at San Jose. **Dr. Samuel B. Batdorf,** formerly with Westinghouse Electric Co., has joined the division as consulting staff scientist.

Dr. Daniel T. Sigley, formerly chairman of the Guided Missile Steering Committee and associate director of the General Engineering Laboratories for the American Machine & Foundry Co., has been appointed chief engineer for the Guided Missiles Division of Firestone Tire & Rubber Co. of California.

Sigley

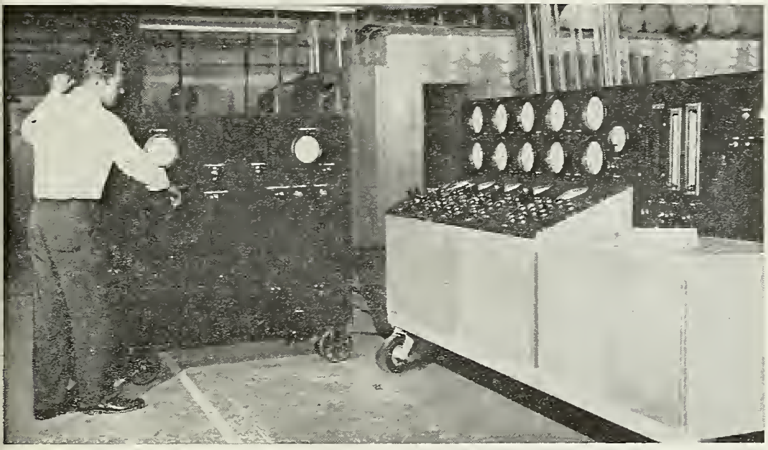
Steinhardt

Lawrence R. Steinhardt has been appointed president of Narmco Metlbond Co., which makes "Multiwave," a sandwich core material used in aircraft and missile structures.

William C. Foster is the first formally-elected Chairman of the Board of Directors of Reaction Motors, Inc.

William M. Duke, former vice president of the Cornell Aeronautical Research Laboratory, has been named program director for the "Titan" Intercontinental Ballistic Missile program of the Ramo-Wooldridge Corp.'s guided missile research division.

NEW MISSILE PRODUCTS

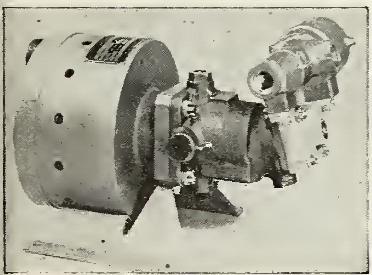


A substantial number of these mobile pneumatic and electrical test stands (right) have been produced by Lear Aircraft Engineering Div., Santa Monica for North American Aviation's Rocketdyne Division to check out rocket engines without firing. Complexity and high-performance requirements of their operation led to design of another auxiliary test stand (left) to check them out.

POWER PACKAGES

Vickers, Inc. has unveiled a series of hydraulic-powered electrical power packages for use in aircraft and missile systems. Although originally designed in the 0.5 to 3.0 kv output range, a larger unit of 10-kva capacity has been adopted for a specific missile installation.

Basic system consists of a permanent magnet, 400-cycle generator directly driven by a flange-mounted Vickers constant-speed



hydraulic motor. Speed control reportedly is within + or —2 1/2% regardless of load and special adaptations will maintain 400-cycle frequency within + or —0.1 percent.

Weight of a 0.5 kva power package is seven pounds whereas a 3.0 kva unit weighs 19 pounds. The larger missile installation in use weighs 40 pounds. Write: Vickers, Inc., Dept. M/R, Box 302, Detroit 32, Mich.

MISSILE CABLE

A new cable especially designed for guided missile motors and electronic controls is available. Designated as Type SP-132, the cable is a four-conductor type with tinned copper conductors, tinned copper braid, polyethylene insulation and a polyvinylchloride jacket. The cable has a minimum outside diameter of 0.275". Write: Federal Telephone and Radio Co. Dept. M/R 100, Kingsland Road, Clifton, N. J.

MISSILE CONNECTORS

Scintilla Division of Bendix Aviation Corp. has introduced two new series of electrical connectors for application in missile ground and airborne systems.

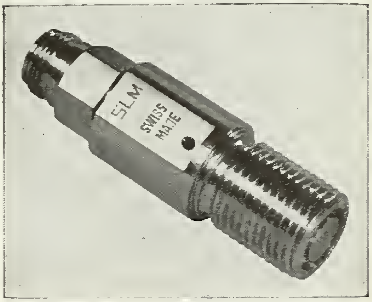
Scintilla's QWL type (illustrated) is designed for heavy-duty use with multi-conductor cables in missile ground launching equipment and ground radar. Tests have indicated absence of thread wear after being subjected to 2,500 coupling and uncoupling cycles.

Other Scintilla series is the "Pygmy" connector intended for miniaturized missile electronic equipment. These are available in "A" and "E" styles, in a series for potting, with jam nut receptacles, and with hermetically sealed receptacles. Write: Scintilla Division, Bendix Aviation Corp., Dept. M/R, Sidney, N.Y.

PRESSURE TRANSDUCERS

New series of Swiss-made miniature SLM pressure transducers available from Kistler Instrument Co. covers a range of pressures from .01 to 100,000 psi. Models are classed as blast gauge, shock-tube gauge, ballistics gauge and hyper-ballistics gauge.

The SLM series is said to be rugged enough to withstand explosions, yet sensitive enough to measure pressure variations in sound waves generated in rocket motors. Units are designed to operate at temperatures up to 600°F and to measure variations as low



as 0.1 psi in fuel systems and combustion chambers at any pressure level to 3,000 psi.

Write: Kistler Instrument Co., Dept. M/R, 15 Webster St., No. Tonawanda, N.Y.

HITEMP DECALS

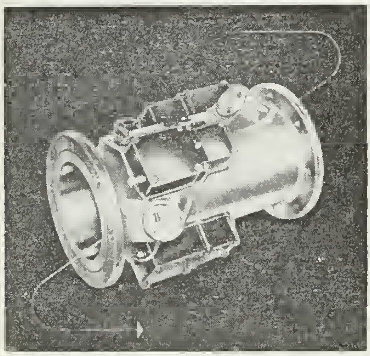
New series of heat and solvent resistant decals designed to withstand higher temperatures of jet aircraft, rockets and missiles have been announced by The Meyercord Co. Applications include engine housings and hot parts, electronic equipment and a variety of situations involving extreme heat.

Three available types of Meyercord decals include: HR—Suitable for most surfaces which will withstand temperatures in

400°F range. SHR—Designates sustained heat resistance. For smooth rigid surfaces under constant operation in 500° to 600°F range. HHR—For high heat resistance. Withstands temperatures up to 1,000°F intermittently. Suitable for rigid surfaces.

Write: The Meyercord Co., Dept., MR, 5323 W. Lake St., Chicago 44.

MISSILE FLOWMETER



An ultrasonic flowmeter marketed by Maxson Instruments Div., The W. L. Maxson Corp., provides simultaneous readout of mass flow rate, mass totalization, volumetric flow rate, volumetric totalization and fluid density in a direct reading instrument for missile fuel gauging systems.

The unit uses ultrasonic energy to determine volume or mass of fluid passing through a smoothbore sensor. It is said to handle up to 720,000 lbs. or 90,000 gals, of jet fuel per hour at an accuracy of 1%. Weight is 10 lbs.

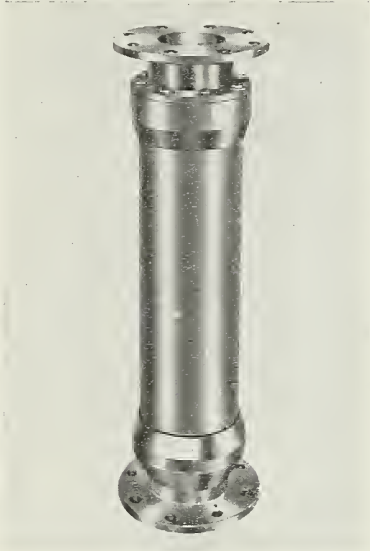
Write: Maxson Instruments Div., The W. L. Maxson Corp., Dept. MR, 47-37 Austell Place, Long Island City 1, N. Y.

LOX STRAINER

A new in-line type stainless steel strainer designed primarily to filter liquid oxygen at extremely low temperatures is marketed by Harman Equipment Co. The Harmeco Model 33008 strainer, said to have application in the ICBM program, is also usable for handling petroleum-type fuels.

New strainer features flanged ends constructed of extremely dense, close-grained stainless steel castings welded to a body of stain-

less steel pipe. Unit is said to be leak-free at temperatures of —350°F and below.



Four available types having optional flange and strainer assemblies all measure four inches in diameter. Weights range from 112 to 135 pounds. Literature available.

Write: **Harman Equipment Co., Dept. MR, 3605 E. Olympic Blvd., Los Angeles 23.**

GEAR TRAIN

Sinite D-10-S bearings are a feature of a new minute gear train announced by Booker-Cooper, Inc. The Sinite material, used by major missile producers in liquid oxygen applications, is a compaction of 50% bronze and 50% lubricative pigments.

Sinite used in bearing applications is said to operate over a wide temperature range at speeds in excess of 3,000 rpm without additional lubrication. Temperatures range from —300°F to +500°F. The material is available in bar stock or is machined to specifications. Write: **Booker-Cooper, Inc., Dept. MR, 6940 Farmdale Ave., No. Hollywood, Calif.**

THERMOCOUPLE JUNCTION

A miniature, multi-channel "hot" thermocouple reference junction which the manufacturer says is rugged enough for missile use operates from ac or dc and is stable to 1.5°F.

The unit can be provided for any type junction such as iron-constantan, chromel-alumel, copper constantan and others. The unit replaces ice bottles and temperature compensators. Write: **Arnoux Corp., Dept. M/R Box 34628, Los Angeles, Calif.**

INSULATED CABLE

New series of single and multiconductor Teflon-insulated cables for missiles and radar applications, high temperature instrumentation and telemetering devices is marketed by Tensolite Insulated Wire Co., Inc. Standard and custom-designed constructions varying from one through 37 conductor assemblies are available.

New cable features parallel-wrapped Teflon, but spiral-wrapped or extruded Teflon primary insulation may be specified. Write: **Tensolite Insulated Wire Co., Inc., Dept. MR, 198 Main St., Tarrytown, N. Y.**

MISSILE TUBES

A new line of seven subminiature tubes for guided missile applications has been announced by Sylvania Electric Products Co. The line includes rf pentodes, beam

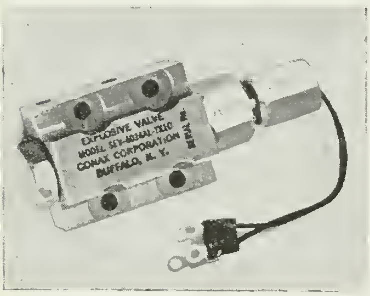
(More New Products, Page 125)

power pentode, audio amplifier, medium and high μ single and double triodes.

Design features include a shorter mount for rigidity, wide element spacings and vibrational noise control over a wide frequency spectrum. Although developed for guided missile application, the tubes are expected also to find application in telemetering and vehicular use. Write: **Sylvania Electric Products Co., Dept. M/R, 1740 Broadway, N. Y. 19, N. Y.**

EXPLOSIVE VALVE

A new normally-closed explosive valve announced by Conax Corp. is designed to provide a dead-tight, shut-off valve for long or short-term storage of gas or liquid under high pressure. When fired by a small integral squib, it opens the equivalent of a 9/32-inch diameter orifice in .002 seconds. Only 1/2 ampere is needed to fire the squib.

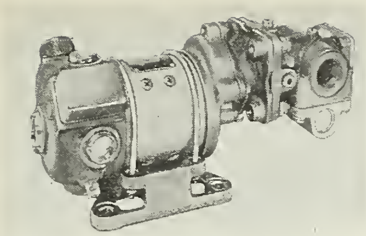


Smallest Conax valve weighs five ounces and is a 1-inch hexagon measuring 3 1/2 inches long. Maximum operating pressure is 5,000 psi and proof pressure is 10,000 psi. Literature available. Write: **Conax Corp., Explosive Products Div., Dept. M/R, 7811 Sheridan Drive, Buffalo 21, N.Y.**

FUEL PUMP

Lear, Inc., Lear-Romec Division has developed a nine-pound rotary vane-type pump designed to supply smoke fuel for guided missile tracking systems. An electric-motor-driven type, it cycles on and off at two-second intervals to create a vapor trail from the tail end of a missile.

Unit is designated Model RG-15800. It has a rated capacity of 4.1 gpm at 27 volts d-c and 13.5 amps pumping Corvus Oil and JP-4 fuel at a two-to-one volume mixture. Displacement is 0.386 cu. in. per



revolution, and a relief valve bypasses full flow at 120 ± 5 psi.

Explosion-proof motor for the RG-15800 is rated at 0.34 hp at 3,000 rpm and 27 volts d-c. Literature available. Write: **Lear, Inc., Lear-Romec Div., Dept. MR, Elyria, O.**

SWIVEL JOINTS

Barco Manufacturing Co. has introduced a new series of aircraft-type swivel assemblies said to provide unlimited flexibility in piping or tubing lines of airborne equipment and track vehicles.

Two basic types provide AN flared or Ermetto fittings in aluminum, steel and stainless steel for pressures up to 4,000 psi. Units are available for handling hydraulic, air oxygen, fuel and acid applications and for temperatures ranging from —300°F to +700°F. Write: **Barco Manufacturing Co., Dept. MR, Barrington, Ill.**

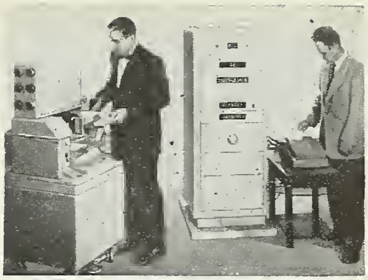
VACUUM PUMP

A new rotary-vane type vacuum pump developed by Beach-Russ Co. for aircraft and missile applications weighs 7 lbs., complete with 28-volt d-c motor. Overall dimensions are 7" x 4" x 6". Write: **Beach-Russ Co., Dept. M/R, 50 Church St., New York 7, N.Y.**

MISSILE CHECKOUT SYSTEM

An automatic system for checking dc and ac voltages and frequency values, together with go/no-go checks has been developed by Electro Instruments, Inc. Both printed and indicator readings are provided. Three groups of devices are used for checkout. These are program, control, and measurement. Programming is done by a punched tape memory.

According to the manufacturer, the system provides dc voltage checks to an accuracy of 0.01% and ac checks to 0.1%. Frequency deviation in percent from

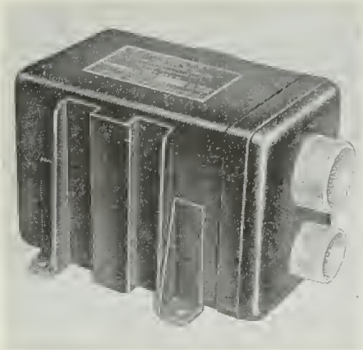


400 cycles is provided with 1 digit accuracy. One hundred channels may be checked. Testing is done automatically and prints identification of tests showing either values or go/no-go indication. Write: **Electro Instruments, Inc., Dept. M/R, 3794 Rosecrans St., San Diego 10, Calif.**

MISSILE FIRE CONTROL

An intervalometer developed by Abrams Instrument Corp. provides automatic programming for missile launching. Opening of rocket pods, rocket-launcher extensions and other functions in sequence are controlled to millisecond accuracies, according to the manufacturer.

No special shock mounts are



required for the unit design to meet MIL-E-5272, Procedure L. Timing is done by a "Chronopulse" time generator. This is a high accuracy dc time base developed by Abrams. Write: **Abrams Instrument Corp., Dept. M/R 606 E. Shiawassee St., Lansing 1, Mich.**

VIBRATION PICKUP

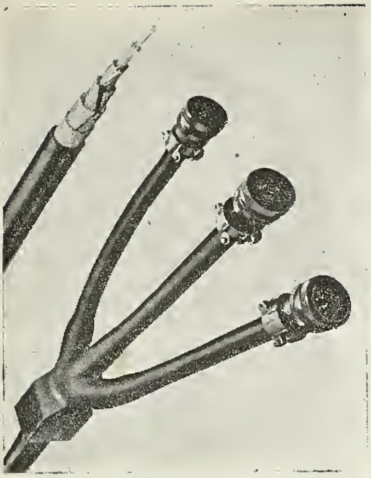
A vibration pickup preamplifier manufactured by Bruel & Kjaer is being marketed by Brush Electronics Co. for use as a link between accelerometers or any type of vibration pickup. The Model BL-1606 is a two-stage unit with high input impedance and allows vibration pickup to be carried out to very low frequencies at extended distances from the measuring instrument.

A built-in calibration unit, consisting of a vibrating disc suspended on a metal strip brought

into resonance at the line frequency gives direct calibration of the combined accelerometer, accelerometer, preamplifier and measuring instrument before the measurements are carried out. Write: **Brush Electronics Co., Dept. M/R, 3405 Perkins Ave., Cleveland 14, Ohio.**

BREAKOUT CABLES

Pacific Automation Products, Inc. is producing a neoprene-sheathed, water-tight "breakout"



cable for missile wiring that contains 141 conductors. It is designed to withstand short-term exposure to oils, acids, alcohol, ozone and water as well as long-term exposure to sunlight.

The multi-branch, multi-conductor cable is layed by a specially constructed planetary strander. It is said to retain flexibility from —65°F to +175°F. Write: **Pacific Automation Products, Inc. Dept. M/R, 1000 Air Way, Glendale, Calif.**

● RADIO RECEPTOR CO., INC. has developed a 2.5-pound airborne miniature radar beacon AN/DPN-43 for ground-crew tracking of missiles in flight. Fully transistorized, it contains more than 120 components in a 6-in. high, 2.5-in. diameter package. Write: **Radio Receptor Co., Inc. Dept. M/R, Brooklyn, N.Y.**

● High "g" event recorder introduced by PHOTRON INSTRUMENT CO. weighs less than 6 lbs. and is said to have recorded thru-shocks in excess of 3,000 g's in actual tests. Unit records up to 21 channels on electro-sensitive paper. Write: **Photron Instrument Co., Dept. M/R, 6516 Detroit Ave., Cleveland 2, O.**

● Specialized line of explosive igniters for initiating solid propellants and liquid fuels are available from McCORMICK SELPH ASSOCIATES. Where igniter requires less than five grams of explosive, squib is integral. For larger sizes, provision is made for thread-in squib. Write: **McCormick Selph Associates, Dept. M/R, 15 Hollister Airport, Hollister, Calif.**

Missile Literature

TEST CHAMBERS. Four-page bulletin describes test chambers built by Inland Testing Laboratories to satisfy virtually any combination of environmental conditions. Refer to Newsletter 3-556. Write: **Inland Testing Laboratories, Dept. MR, 1457 Diversey Blvd., Chicago 14.**

SERVO MOTORS. A 16-page booklet outlines specifications and design details of a line of servo motors and generators. Write: **G-M Laboratories, Inc., Dept. MR, 4300 No. Knox Ave., Chicago 41.**

COMPUTERS. Bulletin illustrates computers, recorders, servos and integrated systems. Write: **Mid-Century Instrumatic Corp., Dept. MR, 611 Broadway, New York 12, N. Y.**

HI-TEMP ALLOY. Alloy R-235, a wrought, nickel-base aluminum and titanium bearing precipitation-hardening alloy for temperatures through 1,750°F is described in new 12-page booklet. Write: **Haynes Stellite Co., Dept. MR, 30-20 Thomson Ave., Long Island City 1, N. Y.**

MISSILE SUPPORT EQUIPMENT and airborne electronic equipment manufactured by Hallamore Electronics Co. is illustrated in new 20-page brochure. Write: **Hallamore Electronics Co., Dept. MR, 2001 E. Artesia St., Long Beach 5, Calif.**

RECORDING SYSTEM, Project Digest PD-21 published by Cook Research Laboratories, Inc. describes newly developed three-channel and six channel magnetic tape recording units for missile instrumentation where space limits are severe. Write: **Cook Research Laboratories, Inc., Dept. MR, 2700 N. Southport Ave., Chicago 14.**

PRECISION SEALING RINGS. Eight-page brochure available from Precision Piston Rings, Inc. gives specifications on eight types of wrought-alloy rings including Haynes Stellite, rated for temperatures of 2,000°F. Write: **Precision Piston Rings, Inc., Dept. M/R, 1417-1423 Commerce Ave., Indianapolis 1, Ind.**

Industry Highlights

By Fred S. Hunter

The Santa Susanna hills on the fringe of Los Angeles used to be a favorite location of the movie makers. You've seen them on the screen of your neighborhood theater—or on your television screen—many times; you just thought that was Montana or Wyoming you were viewing. But now the pop of the cowboy's trusty six-gun has been silenced by the shattering blasts of rocket engines echoing over the hills. For this one-time scene of the old west is today a symbol of the new west. Here is the biggest rocket engine test center in the Western Hemisphere—Rocketdyne's field test laboratory. Here, power for the so-called ultimate weapon, the ballistic missile, is being developed.

•

Out to catch up with North American's Rocketdyne in the development of big liquid rocket engines for the ballistic missile program is Aerojet-General, whose test facility is in the old gold-mining country east of Sacramento. When complete, these huge rocket engine test installations will provide Aerojet's Sacramento plant with 24 test positions, the largest of which can handle engines up to 1,000,000 pounds thrust. Like North American, Aerojet has production contracts for rocket engines for the Air Force's long-range ballistic missiles, including the ICBM Atlas and Titan and the IRBM Thor.

•

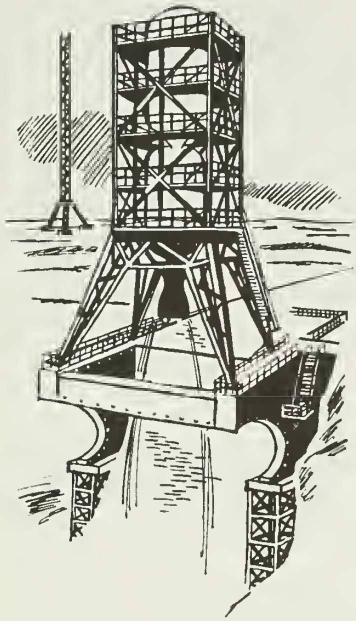
A new $13,000,000 manufacturing plant to be completed in the spring of 1957 will boost the total investment in facilities at Aerojet's Sacramento location to $50,000,000. Originally Aerojet was to have operated a similar $13,000,000 plant at Neosho, Mo., but after construction was started the Air Force decided to divert this one to North American, which is already turning out production type engines, and let Aerojet build another plant in conjunction with the facility it already had at Sacramento.

•

Turbo division of American Machine & Foundry is planning a superenvironmental test chamber capable of simulating the rapid temperature, atmospheric pressure and relative humidity changes encountered by a ground-to-air missile flashing from sea level to 110,000 feet altitude in 100 seconds for its new plant at Pacoima, Calif. AMF's Turbo division is moving up fast. Three years ago at this time, it was a department of the company comprised of 17 people. Now it is heading toward a payroll of 500. It attained division status in the AMF organization last spring and dedicated its new plant in August. Turbo makes accessory power drives for the Nike and has a development contract for units for the ballistic missile program.

•

Horning-Cooper's ASP (Atmospheric Sounding Projectile) developed for the Navy to gather meteorological information and study upper atmosphere cosmic ray and geomagnetic phenomena, also is expected to find additional uses in the hypersonic testing field because of its high velocity. Powered by a high-performance solid propellant developed by Grand Central Rocket Co., the ASP will reach speeds of Mach 5 and better within a few seconds after launching.



NEW STEEL

FOR

TEST STAND, LAUNCHER AND GANTRY TOWER CONSTRUCTION

Heat No.	Plate Thickness, inches	Hardness, RC	Ductility-Transition Temperature, °F
35P489	½	23.5	—195
29S144	½	20.3	—170
35S463	½	22.0	—152
35S463	½	24.4	—162
36S462	½	25.0	—210
37S532	½	28.5	—175
29S515	½	27.9	—235
37S525	½	27.1	—208
34S477	¾	27.0	—195
41S463	¾	25.5	—220
47S464	¾	25.0	—175
41S451	¾	22.5	—205
35S476	¾	24.1	—245
36S462	¾	20.2	—255
29S515	¾	22.9	—225
29S144	1	21.0	—195
34S267	1	24.0	—248
34S477	1	22.9	—190
35S476	1	27.0	—195
27S564	1	26.5	—252
37S532	1	23.6	—242
32U029	1	24.0	—230
73U115	1	25.9	—175
31U033	1¼	24.8	—210
29S144	1¾	24.4	—212

Ductility-Transition Temperatures and Hardness of T-1 Steel Plates

Increased activity throughout the United States in construction of missile- and rocket-launching sites, exceptionally large test stands, gantry equipment, heavy ship launchers and related components will grad-

Need for new materials for the missile and rocket industry is consistent. High temperature and great stresses, fine tolerances and extreme precision are typical requirements. These parameters are indicative of the challenge that materials manufacturers are faced with, and they involve problems of design, material selection, application and fabrication techniques.

MISSILES & ROCKETS' editors, as a special service to its readers, will introduce the many new materials applicable to the M & R industry on these pages in forthcoming issues. Metals/alloys, synthetics and chemicals all will receive attention.

ually yield more business to the steel industry.

In this connection MISSILES & ROCKETS' survey of available new constructional steels focused on T-1, a low-carbon, quenched and tempered alloy that is finding wide use in special construction. The properties of T-1 seem to suit it especially to application in pressure vessels, test stands, cranes, gantry towers, liquid gas tanks and general industrial equipment.

This new, all purpose steel was developed to meet the need for a steel, primarily in plate form, possessing a very high yield strength (90,000 psi or more) and yet tough enough to withstand unusual impact or abrasion abuse or pressures at either low or high temperatures.

● **In equipment fabrication**, the use of T-1 steel makes possible lighter weight equipment because of the unusual yield strength of the steel, which permits reduced plate thicknesses in comparison to the thicker and therefore heavier plates of carbon steel ordinarily used. This can result in substantial over-all savings in material, fabrication, construction and maintenance.

T-1 has a yield strength three times that of ordinary carbon steel according to the manufacturers. Fabrication is no problem to the equipment builder, because T-1 steel is readily welded without preheating or stress-relieving. Its toughness and resistance to the combination of wear and impact abuse cut maintenance and replacement costs, lengthen equipment life.

In the construction industry, where field work is an extremely important facet on nearly every operation, T-1 steel seems to offer many advantages. With no pre- or post-heating required in most cases, equipment can be easily fabricated right on the job site or in the weld shop—whichever is more convenient and less costly.

When the high strength of T-1 steel is used to reduce the thickness of welded sections, welding time and the amount of welding rod needed are reduced.

Lighter weight construction with T-1 steel reduces shipping, handling and material costs, and, in addition, reduces the cost and weight of any foundations and supports that might be needed. Static test stands, for example, are a good example of how T-1 steel can be used to advantage. Parts of large towers and test stands, particularly tension members, subject to high working stresses, as well as parts where resistance to atmospheric corrosion is important or where welding is involved, are suitable for the substitution of T-1 steel.

● **In wind tunnels**, too, T-1 steel apparently can pay off in long-term economy through lengthened service life.

One major advantage that T-1 steel has over ordinary carbon steel is in its resistance to atmospheric corrosion. Designed to include this cost-saving characteristic among its many unusual properties, T-1 steel is suitable material for test stands and equipment used outdoors year-round.

The results of recent short time exposure tests by Lukens Steel Corp. are shown here. In these tests, this new steel was compared with structural copper steel, as well as with Cor-Ten steel. Structural copper steel is assumed to have twice the atmospheric corrosion resistance of carbon steel. Cor-Ten has four to six times the atmospheric corrosion resistance of ordinary carbon steel.

Based on the following test data, it is conservatively estimated that T-1 steel has at least four times the atmospheric corrosion resistance of ordinary carbon steel.

Temperature °F	Stress, psi	Time to Rupture, hours	Elongation in 1 inch, per cent	Reduction of Area, per cent	Minimum Rate of Extension, per cent per hour
900	80,000	2.95	18.0	63.4	0.9333
900	77,500	49.8	15.8	47.2	0.0351
900	75,000	108	8.0	28.2	0.0231
900	70,000	252	5.2	11.1	0.0100
900	60,000	818	1.2	1.2	0.0022
1000	75,000	0.27	18.2	63.0	7.6
1000	60,000	13.4	6.2	11.8	*
1000	30,000	35.6	3.8	3.3	0.572
1000	35,000	190	2.0	2.8	0.0089
1000	24,500	797	2.8	0.41	0.0023
1100	60,000	0.1	18.4	59.6	32.0
1100	40,000	3.2	5.8	6.9	1.04
1100	30,000	12.9	4.9	4.9	0.1530
1100	20.000	66.6	4.2	3.7	0.039
1100	10,250	963	11.8	8.3	0.0062

Results of Creep-Rupture Tests

Steel	Test Temperature, °F	1% Creep in 10,000 Hr.	Stress, 1,000 psi for Rupture in 1,000 Hr.	Stress, 1,000 psi for Rupture in 10,000 Hr.
"T-1"	700	96.0	98.0	94.0*
"T-1"	900	44.0	59.5	44.0
"T-1"	1,000	10.5	23.0	13.8
"T-1"	1,100	2.3	10.0	5.8

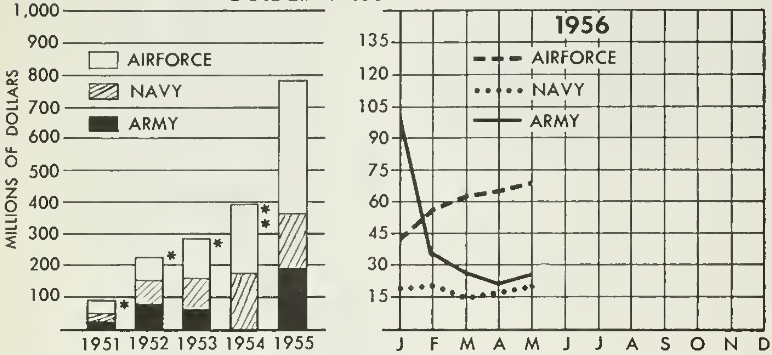
Creep and Creep-Rupture Data

Location of Test Rock	Kearny, N. J. .5 yrs.	Kearny, N. J. 1.5 yrs.	Kure Beach, N. C. .5 yrs.	Kure Beach, N. C. 1.5 yrs.	South Bend, Pa. 1.5 yrs.
"T-1" Steel	5.0	8.2	2.8	5.9	7.1
Str. Copper Steel	7.9	17.0	3.9	10.2	9.8
Cor-Ten Steel	5.1	7.5	2.7	5.6	6.3

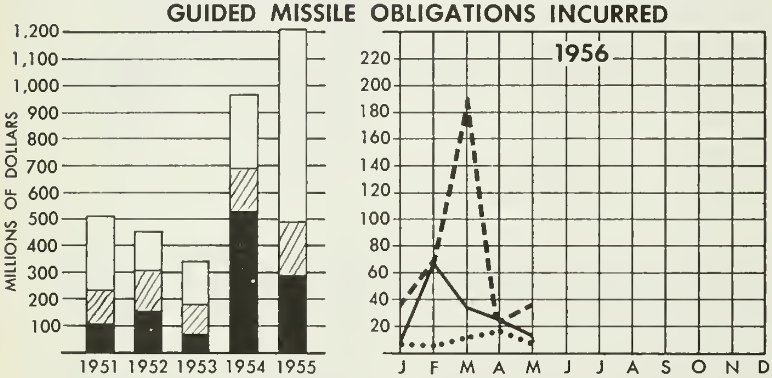
Loss of Weight, Grams per 4-x-6-inch Specimen

INDUSTRY BAROMETER

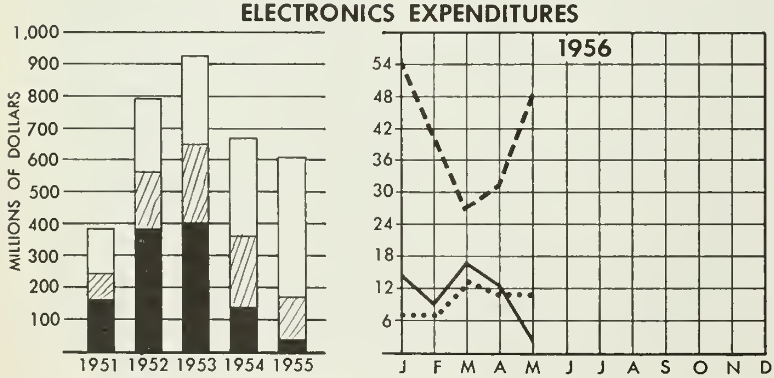
GUIDED MISSILE EXPENDITURES



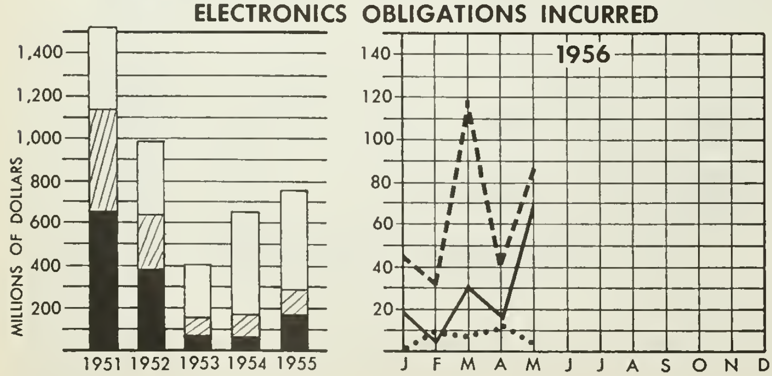
GUIDED MISSILE OBLIGATIONS INCURRED



ELECTRONICS EXPENDITURES



ELECTRONICS OBLIGATIONS INCURRED



How is the Government spending our money for guided missiles? This is a question that has been agitating the minds of engineers and management personnel as well —ever since the overall missile budget exceeded the billion-dollar mark.

MISSILES & ROCKETS has taken a close look at the total picture and has compiled the facts and figures graphically. Since electronics and communications equipment are closely allied to missile development and production, Department of Defense expenditures and obligations for this industry have also been summarized.

A comparison of programmed R & D obligations by fiscal year for missiles and aircraft is shown. These figures are presented as a guidepost to total activity in missile R & D. Recent testimony before Congress indicates that additional obligation funds can be and have been transferred from other budget categories to meet extraordinary missile R & D demands. The Department of Defense does not release expenditure data on missile R & D.

The minus $456,000 expenditure by the Army for 1954 represents a gain in funds rather than an expenditure figure. In January, February, May and June of 1954 the Army received substantial reimbursements for work performed for the Navy and the Air Force. More than one missile program was involved in these reimbursements. The electronics and communications expenditures account includes money spent for radar, electronic and electromechanical computers, radiation aids to aircraft and navigation, radiation aids to fire control and bombing, radiation countermeasures, meteorological equipment, etc. It is apparent that large electronics purchases by the Army are likely to take place during the next few months.

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* Estimated

** Includes—$456,000 Army expenditures Army deobligated $15 million in May '56 (See graph titled "Guided Missile Obligations Incurred.")

Book Reviews

ROCKETS AND MISSILES. *By John Humphries, 229 pp. $6.00. Ernest Benn Ltd., London. Distributed by The MacMillan Company, New York.*

This book is a rather simple introduction to the subject matter. The publisher says it is written mainly for engineers and technicians, but the material actually is handled in a semi-technical manner. Of particular value are the numerous cutaway drawings of rockets; an extensive bibliography is of considerable interest. The photographs are not too significant, but many of the graphs are good.

The first half of the book covers propellants, motors and components, the second the applications of these to missiles and aircraft.

The chapter on testing of motors and liquid propellants is quite interesting. In general, the book may merit consideration for vocational purposes, since it covers many outstanding basic phases of the missile and rocket industry of importance to the engineer who is about to enter the field or to the student who plans to do so.

THE MEN BEHIND THE SPACE ROCKETS. *By Heinz Gartmann, 185 pp. $3.95, David McKay Company, Inc., New York.*

Although this edition of Gartmann's original *Traumer, Forscher, Konstrukteure* is somewhat condensed, the translators have done a good job.

The book is excellent. It gives a concise, interesting biography of some of the most eminent rocket researchers of our time. Gartmann describes the work and lives of the scientists with whom he has worked and who have devoted themselves to the great ideal of the conquest of space.

The biographies include those of Hermann Ganswindt, Konstantin Eduardovich Tsiolkovski, Robert H. Goddard, Hermann Oberth, Max Valier, Eugen Saenger, Helmut Philip von Zborowski and Wernher von Braun and give an interesting rundown on early German rocketry. The chapters on Dr. Saenger and Helmut von Zborowski are of particular interest in view of their current work on advanced missile and rocket projects.

THE EXPLORATION OF MARS. *By Willy Ley and Wernher von Braun. Paintings by Chesley Bonestell. 176 pp. $4.95, The Viking Press, New York.*

This book belongs in every rocket and astronautics enthusiast's library. Ley and von Braun have succeeded in introducing a down-to-earth approach to the long-awaited trip to Mars. Sticking strictly to engineering knowledge available today, the authors have outlined a master blueprint for man's first voyage to Mars.

Landing on Mars

The text is supplemented by a Mars bibliography of great value, tables, diagrams, historical and modern maps, and five black and white and 16 full-color reproductions of paintings by Chesley Bonestell of usual superb quality.

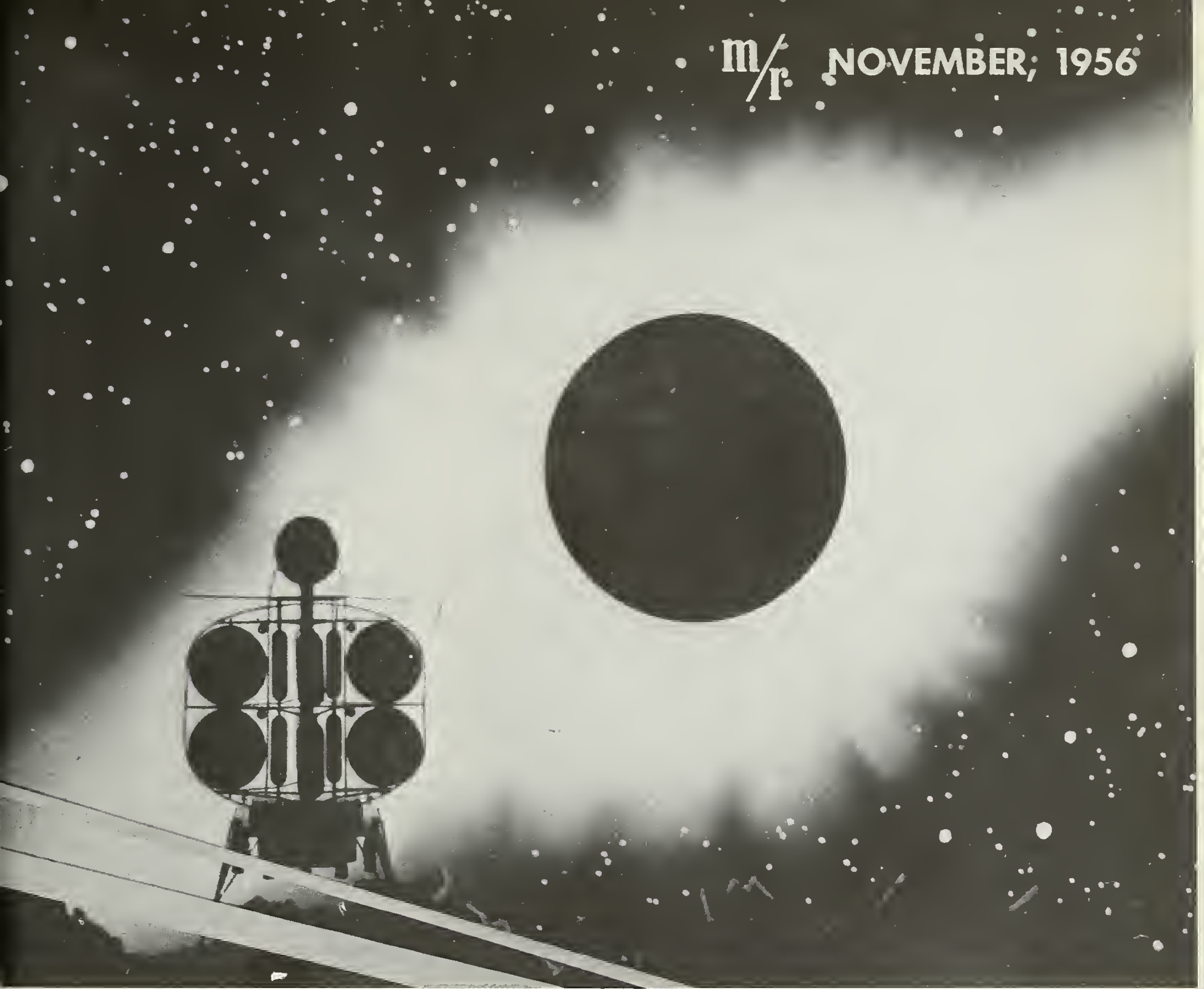
CONTROL OF NUCLEAR REACTORS AND POWER PLANTS. *By M. A. Shultz, 313 pp, $6.40, McGraw-Hill Book Co., Inc., New York. Number two of a series in Nuclear Engineering.*

Based upon recognition that the nuclear-power business is in the transition stage from physicists to the engineers, the book gives an elementary picture of control systems. The approach is: Given the reactor, how to control it?

Control problems described are handled through conventional and elementary servo forms and language. This is done despite the fact that synthesis and design of reactors is steeped in mathematics and clothed in security.

Because of this, certain assumptions and simplifications about the reactors are made in regard to design of the control systems for them. The book is an excellent exercise in the philosophy of designing for the new field. A chapter is devoted to an exercise in design of electronic simulation techniques for study of control problems. For use in teaching, a section is given to question problems related to each chapter.

m/r NOVEMBER, 1956



missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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missiles and rockets

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missiles and rockets

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Army Help For ICBMs?

COULD IT BE THAT THE NATION'S two Intercontinental Ballistic Missile programs—the *Titan* and the *Atlas*—would be much farther along today if the Army had been brought in to assist the Air Force?

So successful has the Army become in the missile field that one wonders if the ICBMs wouldn't be nearing completion, rather than being in their initial stages as they are now, if the programs had been under joint sponsorship.

There's no denying the impressive record being built by Army Ordnance in the Intermediate Range Ballistic Missile programs. In view of the performance to date, one can well begin to ask where the intermediate range leaves off and the intercontinental range begins.

Admittedly the original division of responsibility seemed quite natural and logical. The Army is the artillery agency and, as such, should be concentrating on anti-tank missiles, short-range ballistic missiles, anti-aircraft and battlefield attack rockets. The Air Force, with its responsibility for long-range strategic bombers, seemed the logical agency to assume responsibility for ICBMs.

The recent IRBM test flights at Patrick AFB, however, indicate that the Army's *Jupiter*, which has been scheduled as a 1,500-mile weapon, might well be capable of 3,000 miles. Thusly it will have practically intercontinental range and is, possibly, the most advanced ballistic missile in the free world today.

Since the Army already has three fully-proven operational missiles, namely the *Honest John*, the *Corporal*, and the *Nike*, with three more systems to be put in operation shortly (the *Little John*, the *Dart* and the *Redstone)*, it is perhaps a little puzzling why an agency with such experience and versatility has not been called upon by the Defense Department to help the Air Force in developing its two ICBM programs.

Certainly we don't propose that the Air Force should be excluded from ICBM projects. Far from it. But a joint Army-Air Force program might get faster results.

Three major articles pertaining to various phases of the Army's record in missiles appear in this issue. They testify to the extent and depth of the Army's activity.

WAYNE W. PARRISH

Correction and Clarification

A most unfortunate error, attributable solely to the printer in revising this page, crept into the last paragraph of the editorial in the October issue. As it appeared in type, a sentence read "To ensure *political* quality, we have support without peer." The sentence should have read "To ensure *editorial* quality . . . " (Italics are ours.) No problems of space flight are more baffling than those pertaining to printers who can magically change "editorial" to "political" with all the devilish implications that such an alteration implies.

W. W. P.

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FEATURES

ROCKET ENGINEERING

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NEWS AND TRENDS

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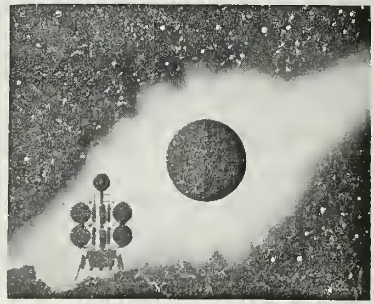
INDUSTRY SPOTLIGHT

IN THE NEXT ISSUE

M/R for December will feature Air Force Missile Power • Complete round-up on Air Force missiles • Air Force missiles research and development • Tabulated data on Air Force missile arsenal • Feature article authors include Dr. S. Fred Singer, University of Maryland; Dr. Peter A. Castruccio, Westinghouse Electric Corporation; Colonel William O. Davis, Office of Scientific Research, ARDC; and others.



Cover Picture

M/R's cover picture shows an eclipse of the sun by the earth as seen from the moon. Increasing interest in astronautics in Japan has been highlighted by a series of photographic compositions by Yasumasa Miyazaki and Toshihiko Sato, produced by the Yomiuri Press for a serial of astronautics entitled "Columbus of Space." A report on Japanese astronautics is given by Frederick C. Durant III, page 48.

COLUMNS

DEPARTMENTS

PHOTO CREDITS:

U.S. Air Force, pp. 14, 15; Moscow NEWS, p. 18; Sovphoto, p. 19; Department of Defense, p. 22; U.S. Navy, pp. 26, 27; General Electric, pp. 26, 62, 63; Radioplane, p. 27; Chrysler Corp., p. 31; U.S. Army, pp. 31, 34, 35, 36, 38, 39, 40, 42; Convair, p. 45; Miyazeki, Sato, pp. 48, 50; A. C. Robotti, pp. 54, 56; NACA, pp. 59, 82, 86, 88, 92; from an R.A.S. report, p. 60; Minneapolis Honeywell, pp. 70, 72; Brooks & Perkins, p. 72; Vickers, p. 78; Aerojet, pp. 90, 91; Martin, p. 124.

Letters

Guidance For Would-Be Missile Engineers

To the editor:

. . . Heartiest congratulations on the first issue of MISSILES & ROCKETS! At last the burgeoning guided missile industry has a voice to reach the interested layman as well as the professional.

I was particularly sympathetic to the problems of 17-year-old Jimmy Blackmon in the article "A Boy and His Rocket." It seems to me that the educational institutions of this country and, to a lesser extent, the Department of Defense, owe this young would-be guided missile engineer an answer to his questions, "Where do I start? What school should I attend? What books should I read?"

The writer is presently serving as Navy Technical Director for the *Jupiter* IRBM and thus is closely associated with Dr. Wernher von Braun, Jimmy Blackmon's advisor and inspiration. I share Dr. von Braun's concern for the proper education of such young men. These are the prospective engineers who will assure the defense of our country and one day turn guided missile technology to the conquest of space. We should leave no stone unturned to whet their intellectual appetites....

Grayson Merrill
Captain, USN

Bureau of Ordnance (Sp)
Department of the Navy
Washington 25, D.C.

To the editor:

. . . Congratulations on your excellent first issue of MISSILES & ROCKETS and best wishes for the continued success of this new venture.

In regard to the comments on page 43, we are attempting a solution with an IGY training program which the RRI has started in Sacramento. Recently a student section was formed for fellows like Jimmy Blackmon. Based on our experiences here, we hope to start similar training programs in other parts of the country within a year or so . . .

George S. James, Director
Rocket Research Institute

3262 Castera Avenue
Glendale 8, California

To the editor:

. . . Having just seen your fine publication for the first time last night, I just want to let you know that I feel you have done a wonderful job in bringing forth such an excellent trade publication in so vital a field. The content of the first issue of MISSILES & ROCKETS reflected a vigorous, successful effort on the part of the AAP staff, and all of us will be looking forward to the subsequent issues . . .

Harry S. Baer, Jr.
Aeronautical Training Society
1115 Seventeenth Street, N.W.
Washington 6, D.C.

To the editor:

. . . Congratulations on the first issue of MISSILES & ROCKETS, which is bound to become "top money winner" in your fine stable of outstanding aviation publications.

I think the outstanding article was the one on "Teamwork" by our mutual friend, Dr. Wernher von Braun, who I believe has done more to wake up the American people to the "Age of Rockets" than anyone else. Certainly, his timely article on the importance of working together and also doing something concrete about interesting young men in the fine future this field holds, will be seconded not only by industry, but also by those of us in aviation education . . .

Gene Kropf
Assistant to the Dean
Saint Louis University
Parks College of Aeronautical Technology
East Saint Louis, Illinois

Satelloid Up There Already?

To the editor:

. . . Congratulations on an exceedingly fine first issue of MISSILES & ROCKETS. How many first-issues can boast of 152 slick pages?

I found your article querying "Army to Launch 'Satellite' Before Vanguard?" of noteworthy interest. One cannot help but wonder at times if an orbital satelloid may not have already been established . . .

Max B. Miller

1420 South Ridgeley Drive
Los Angeles 19, California

Russians Ahead?

To the editor:

. . . My congratulations on the new magazine. The first issue was terrific and I sincerely hope you will be able to maintain the caliber of this.

In speaking with our John Streeter I suddenly had an idea and it is simply this. I think the time has come for a thinkpiece concerning the visibility of the satellites we are going to put into the sky. We find that the Project *Vanguard* satellite cannot be seen with the naked eye. However, for less payload than the twenty-two pounds for the instrumented satellite, the inflatable balloon idea can be consummated to yield significant geodetic information and be quite visible to the naked eye. We can all be assured that the Russians are going to put a satellite into the sky before us, or if it is after us you can bet it will be readily visible. This is one advantage we should not let go by default. Again my very best wishes in this new venture . . .

I. M. Levitt, Director
Fels Planetarium
Franklin Institute

Philadelphia 3, Pennsylvania

M/R Appearance Praised

Cablegram:

. . . Your new publication, MISSILES & ROCKETS, is a wonderful job and a great contribution to this up and coming industry. The appearance, typography and content are a tribute to you and your organization . . .

E. Theodore Stern
Mannie Berlinrut
Douglas Aircraft Company

New York City

To the editor:

. . . Congratulations on an excellent first issue; I'm looking forward to the next ones. I especially enjoyed the short "News Section" for current information . . .

Robert W. Garner
Project Engineer
John I. Thompson & Company

Washington 6, D.C.

NEWS and TRENDS

U. S. AIRCRAFT ROCKETS—HOW GOOD?

Pilots Prefer 2.75-inch *Mighty Mouse* to Heavier Weapons; Better Fuses and Computers Sought

By Henry T. Simmons

Yuma, Ariz. — Should an air attack be launched against the U.S. this minute, the nation's first line of defense would NOT be a potent array of airborne guided missiles.

Despite the years and the hundreds of millions of dollars poured into development of the smart birds, a small, unpretentious and unguided rocket is still the nation's principal air weapon against enemy attack. It is the MIGHTY MOUSE, a 2.75-inch rocket developed by the U.S. Navy.

The importance of the small "FFAR" (Folding Fin Air Rocket) was amply illustrated at the Air Force interceptor competition, staged at Vincent AFB here. The FFAR was the only weapon used by the nine USAF interceptor teams battling for first place; more than 5,000 of the small rockets were fired at the 9 by 45-foot nylon banners towed at various altitudes across the firing range during the course of the meet.

First place was taken by the 94th Fighter Interceptor Squadron, representing the Eastern Air Defense Force. Flying the North American F-86D, the unit racked up 13,800 points out of a total possible score of 24,000. Second place went to a team representing the Western Air Defense Force. Using the Northrop F-89D—the only other interceptor entered in the meet—it accumulated 11,400 points.

Pilots Disagree on Effectiveness

There was considerable disagreement among the pilots over the relative effectiveness of their weapons, even after the scores were all in. The F-86 pilots felt that the direct 90-degree rocket firing system made possible by the location of all rockets in a retractable tray beneath the F-86 cockpit gave them an edge over the converging type of rocket firing necessitated by the wingtip pods of the F-89D. But pilots of the latter aircraft did not feel this provided the F-86D with superiority since the Northrop machine can launch up to 104 rockets in a salvo from the wing pods against only 24 from the F-86D. During the meet, however, all pilots were restricted to salvos of 24 rockets, regardless of the capability of their aircraft.

One thing the pilots did agree on was the effectiveness of the 2.75-inch FFAR as an air weapon. Declared one competitor: "I don't think you can find a better rocket than the 2.75. Even if a fin hangs up, you get a barrel-rolling effect so the individual rocket won't oscillate more than 10 feet from a straight line."

The principal of the small rocket is that of the shot-gun. If enough of them can be fired into a given volume of space, it is almost mathematically impossible that an intruding aircraft or target banner can escape at least one hit by the contact-fused rockets. Since each one packs a wallop equivalent to a 75 mm cannon shell, it is doubtful whether even the largest aircraft could survive a single hit.

FFAR measures 48 inches in length and 18.5 pounds in weight, of which 3.5 pounds is allocated to the warhead. Powered by a double-base solid propellant, it is capable of a maximum velocity of about 2,600 feet per second (Mach 2.7 at altitude) and has a burnout time of about 1.5 seconds. The thrust during this brief period is about 800 to 900 pounds and the acceleration is on the order of 50 gravities. Exact performance specifications remain classified, however.

Navy developed the FFAR dur-

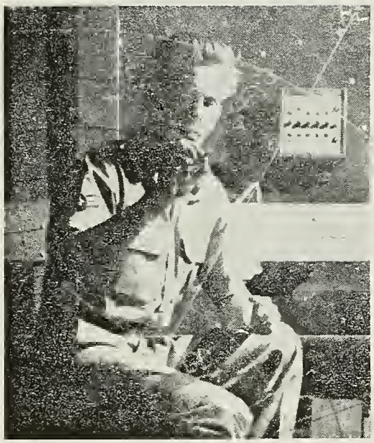
"The gun is about finished as a primary fighter weapon, although it may be useful in an auxiliary role. Its duties for the most part will be taken over by the guided missile, with assistance from the free rocket."

Speaking is a veteran pilot instructor stationed at Nellis AFB—the fountainhead of Air Force fighter tactics and doctrine. While his view may not reflect the official position of the Air Force, it is nevertheless significant because Nellis for many years has been the principal support of machine gun and cannon armament for fighters within the USAF.

"Guided missiles would probably take over the whole shooting match if they were not subject to enemy countermeasures," he observes. "In the case of radar-guided missiles, large bombers have a distinct advantage over small fighters. They can generate far more powerful interference than the radar guidance signals from the fighter."

"Because of this, I believe that infra-red homing weapons like the *Sidewinder* stand a better chance than the radar-guided *Falcon*. But the *Sidewinder* can be fooled, too; in fact, I suppose any air-to-air missile we develop can be jammed.

"For this reason, I believe the free rocket and, to a lesser extent, the gun will stay with us as secondary weapons. Although less accurate than missiles, they are immune from jamming and might spell the difference between success and failure in the event of superior jamming ability by the enemy."



All rocketry work at the Vincent AFB interceptor competition was out of sight, so plotting boards like this were used to keep team members abreast of the meet. "Judy" occurs when the interceptor's radar "locks on" the target.

Careful handling of the 2.75-inch rockets is necessary to prevent cracks in the propellant which could cause uneven burning or even premature burnout. Metal cans ground the firing mechanism to prevent accidental ignition.

Ground radar controllers maintain a continuous plot of the area, vectoring the fighters into the targets with course instructions. Aircraft crew takes over when the interceptor's own radar picks up the bogie.

ing the early days of the Korean War, and it was put into production at the height of that conflict. Present production rate is much lower than the initial rate, with only three principal contractors slated to remain in the program, according to the Navy. They are Aerojet-General Corp., Azusa, Calif., which manufactures the rocket motor and ingenious folding fin assembly; Hunter Douglas Aluminum Co., Riverside, Calif., which makes the tubes, and Heintz Manufacturing Co., Philadelphia, which produces the warheads.

In the past, components for the 2.75-inch rocket have been produced by at least eight other manufacturers. Manufacturing motors were Tecumseh Products Co., Tecumseh, Mich.; Muncie Gear Works, Muncie, Ind.; Colson Corp., Elyria, Ohio, and Landers, Fary and Clark Co., New Britain, Conn. Tubes were provided by Reynolds Metals Co., Phoenix; Aluminum Company of America at New Kensington, Pa., and Norris Thermador Corp., Los Angeles, while C. D. Cottrell Co., Westerly, R. I., manufactured warheads.

Simple Rocket in Complex System

Despite its high performance, the basic simplicity of the weapon holds its price to a reasonable level. Its price tag is on the order of $65, and this has prompted some air crewmen to call them "Car Payments" instead of using the too-cute popular name or the overly-formal military designation.

In actual interception operations, the FFAR is only one part of a complex weapon system which involves the use of elaborate ground control radar installations to vector interceptors to their targets, airborne radar permitting the attacking aircraft to detect and lock on to targets at close range, computers which automatically calculate and represent the course the aircraft must fly to achieve a 90-degree collision intercept and which fire the rockets at the proper instant, and, in some aircraft, equipment which actually takes the aircraft controlls and maneuvers for the intercept. Hughes Aircraft Co., Culver City, Calif., is the exclusive supplier of radar fire control systems for AF interceptors at the present.

This year's meet at Yuma may be the last which the FFAR will dominate exclusively. Next year it is hoped that the *Falcon* GAR-1 missile can be introduced, along with the Convair F-102A interceptor. Should this be possible, it is likely that a separate event will be established for the *Falcon*-armed aircraft which would employ jet-powered drones like the Ryan Q-2 *Firebee.*

Next year's gunnery meet will see guided missiles in action. Weapons to be used will be FALCONS and possibly SIDEWINDERS. The latter, which is shown in this picture, has aroused the Air Force' interest, although missile is developed for the Navy.

Simultaneously with the Vincent AFB interceptor competition, the Air Force conducted its annual day fighter and fighter-bomber competition at Nellis AFB, Las Vegas, Nev. This included air-to-air gunnery as well as air-to-ground events with guns, bombs and rockets, plus a Special Weapons Delivery competition featuring the use of toss-bombing and over-the-shoulder bombing techniques for the safe delivery of nuclear weapons.

2.75-inch Rocket Superior, New Fuse, Computer Sought

Winner of the day fighter phase of the meet for the sixth year in a row was Nellis' own Air Training Command team, flying North American F-86H *Sabrejets*, while a USAFE team flying the same aircraft captured the Special Weapons competition.

Although rocketry was only one small portion of the day fighter meet, Nellis pilots favored the small 2.75-inch rocket over the larger air-to-ground weapons which would be available to them in combat. While conceding that the small warhead of the FFAR lacks enough beef to penetrate heavy armor, even with shaped charges, they find its accuracy far superior to that attainable with the heavier but much slower 5-inch rocket.

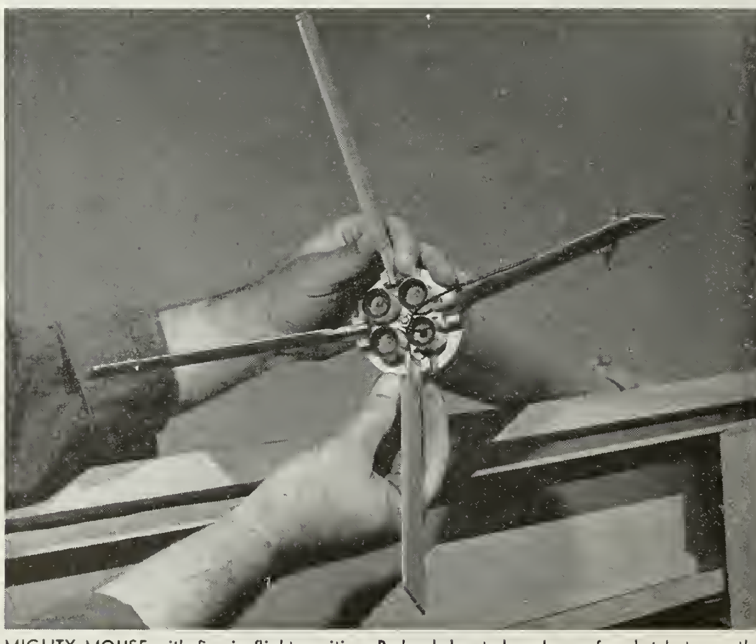
"The 5-inch rocket is too slow and it drops too fast," commented one pilot. "The 2.75 has a much flatter trajectory that the larger rocket, and therefore we can score more hits."

Asked what improvements he would like to see in the small rocket, he replied: "A VT (proximity) fuse to get air bursts over personnel would be a first rate improvement, although I haven't heard of the development of a VT fuse of that size yet. And a computer which would assure accurate air-to-ground rocket fire at any speed and approach would also be a big help."

Like Vincent AFB, Nellis is also looking forward to big changes in the make-up of its competitions. It expects to receive its first Lockheed F-104 day fighters shortly. Ultimately these would be equipped with *Sidewinder* missiles, so that any competitions in which they are involved will require the use of jet drones if realism is to be obtained.

The 2.75-inch MIGHTY MOUSE rocket with fins in the folded position. A small electric impulse traveling from the contact plate through the wire to the base of the motor ignites the rocket.

North American F-86D all-weather interceptor launches a stream of 24 2.75-inch rockets at a tow target high over the Arizona desert near Yuma. Note retractable rocket launching tray beneath cockpit.



MIGHTY MOUSE with fins in flight position. Pushrod, located on base of rocket between the four barrels, is forced to the rear by the expanding gases, engaging lobes at the base of the fins and pushing them into the slipstream.

Rocket Trends

By Erik Bergaust

Apparently, Lockheed's X-17 test vehicle, which is supposed to aid ICBM researchers in their study of heat problem, has not yet reached the high re-entry velocities required. (See page 43).

No. 13 *Viking* rocket is being readied at Patrick for launching on or about the 20th of this month. Experiment has dual purpose: long-range missile people hope to get some data on re-entry problems, *Vanguard* personnel are in the market for launching experience.

You'll be hearing more about Grand Central Rocket Company. A group of ambitious rocket engineers are working on highly advanced solid-propellant applications, some of which are believed to be "tremendous" high-efficiency boosters.

Little publicized fact is that NACA has launched several step-rockets—with as many as four stages—to 200 miles altitude over the Atlantic Ocean. Highest velocity obtained is 7,000 miles per hour. New Navy research missile, the *Iris,* also will climb to 200 miles. Atlantic Research Corporation holds development contract.

U.S. hopes to get permission to use Brazil's Gernando de Noronha and Trinidad Islands (600 miles out into the South Atlantic Ocean) for missile tracking stations.

The Rocket Technical Committee of the Aircraft Industries Association has been subdivided into Liquid Propellant and Solid Propellant Divisions, reflecting increased importance of solid-rocket propulsion.

Northrop's *Snark* isn't quite dead. Mid-Air Equipment Corporation has been awarded a contract for design of checkout facility and test cell for the *Snark.* Built at Hawthorne as part of Northrop's *Snark* production contract, the new facility will be ready for use early next year.

First-stage *Vanguard* engine is operating satisfactorily; one unit already has been shipped to Martin. Gasoline has been dropped as fuel. Special kerosene mixture will be used.

Air Force might be blasting off something real big from Patrick next month: the *Thor* IRBM prototype. Powerplant phase of the program is believed to be in good shape.

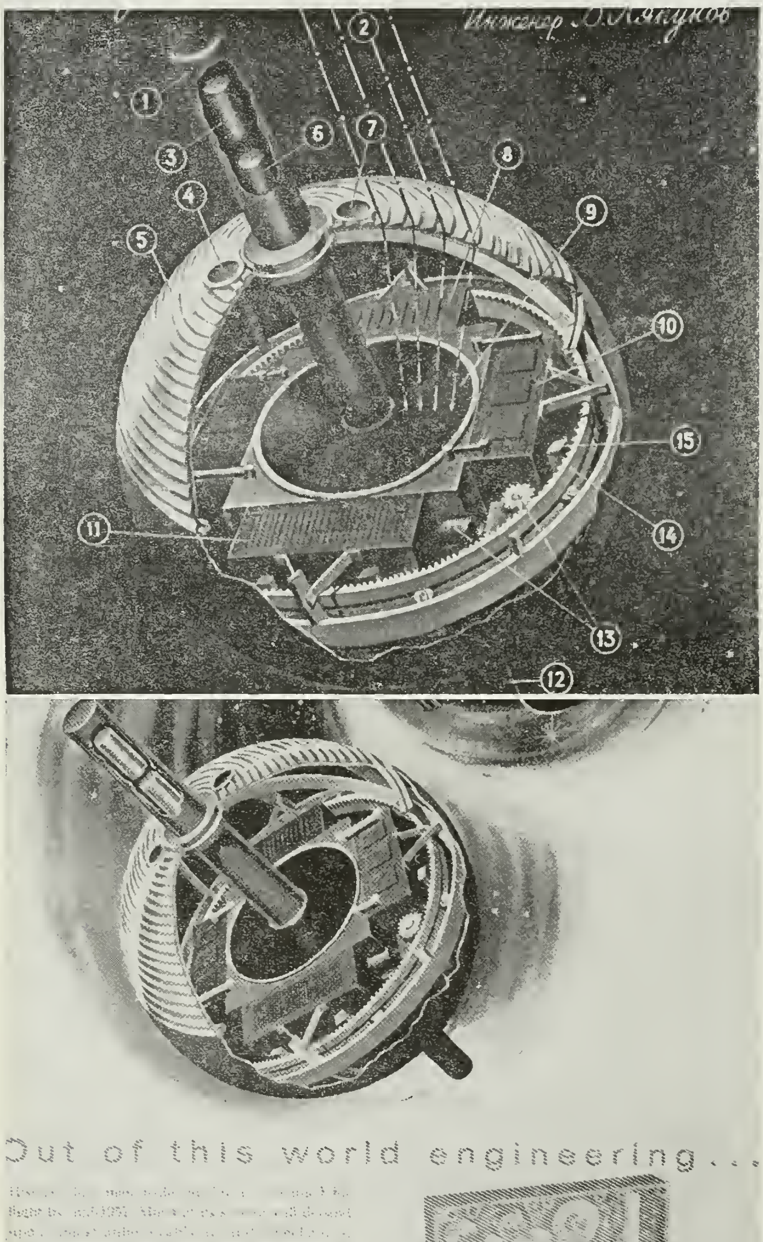
Army has activated its first *Redstone* battalion. This indicates the huge missile has been accepted and will be operational shortly. Chrysler is ready for mass production.

Scaling up a liquid fuel rocket is still an art that results in a debugging test program. Cal Tech is working at eliminating scaling troubles, particularly oscillations in rocket motor during combustion.

Fulton-Irgon Corporation is latest entry into rocket business. New firm, with headquarters at Bernardsville, N. J., will act as consultants in the field of rockets, propellants, escape systems, cartridge devices, launchers and liquid-propellant guns.

RUSSIANS HAVE PROBLEMS:

SATELLITE SCIENCE NOT SO SIMPLE



Here's what the Russian public think their IGY satellites will look like. Illustration (top) bylined "by N. Antonov" in Russian magazine is exact copy of Dr. S. F. Singer's early MOUSE (1954), frequently displayed in this country (bottom).

U.S. Satellite Designs Copied?

By Erik Bergaust

A couple of Russians have tried to convey to the Soviet people how advanced Red scientists are in the art of satellite science. Engineer B. Lyapunov has impressed millions of Russians with a brilliant article on details of what is understood to be the forthcoming Russian IGY satellites. And artist N. Antonov has taken credit for a cross-sectional schematic satellite drawing in the same popular Russian magazine NEWS. What the Russian people don't know is that they have been fooled—the satellite that must have made comrades Lyapunov and Antonov heros overnight, is American.

As can be clearly seen from the illustration on the left, the Russian satellite is a true and exact copy of one of Dr. S. Fred Singer's early MOUSE versions, discussed in Popular Science in July, 1954, and frequently used in Western Gear advertisements. No reference whatsoever is given to any American source.

In his caption—where Lyapunov explains how the automatic artificial earth satellite will "be arranged," he says:

"Its upper side will always be turned to the sun, and the sun's rays (2), passing through the transparent lens (5), will be concentrated on the solar battery (9), which serves to recharge the storage cells (10). The pin (1), serves as the antenna for the radio transmitter (11). The following instruments are installed in the artificial satellite: for studying gamma rays (3), the sun's ultraviolet radiations (4), free electrons (6), X-rays (7), magnetometer (8), measuring device (recorder) for studying the aurora and cosmic rays (12). The readings of all these instruments are recorded on the magnetic tape of the drum (14), which is revolved by the motor with reducing gear (13). The recording hear

(15) controls the recording." Dr. S. F. Singer certainly will recognize this design.

Some details on the forthcoming Russian IGY satellites have been compiled by MISSILES & ROCKETS during the last few weeks from Russian radio broadcasts and from an analysis of several Russian trade journals and magazines.

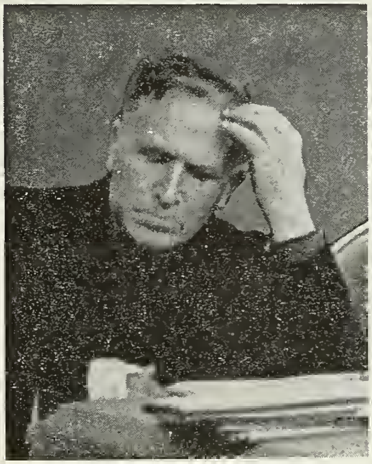
Although the Russian satellite will be of the same size as the American (Professor Georgi Pokrovsky, writing in MOSCOW NEWS, says it will be 20-24 inches in diameter), the Red scientists won't make their orbiter a light-weight device such as the VANGUARD. Russia's satellite will weigh almost 100 pounds, five times as much as the American.

The Soviet carrier vehicle will be tremendous in size compared with the VANGUARD vehicle. Some of the Russian write-ups indicate their vehicle will weigh 150 tons. Pokrovsky said this is approximately 10 times greater than the largest existing rocket. Although Pokrovsky has indicated some sources think the satellite carrier rocket can be made somewhat lighter, he admitted "enormous technical difficulties have to be overcome."

Russian IGY Committee Chairman Professor I. P. Bardin and astrophysicist Professor Leonid Sedov also have admitted the satellite job is formidable. "It is going to take some thinking," Bardin was quoted as having told IGY delegates in Barcelona this fall.

Furthermore, it looks as if the Russians are beginning to realize that the only solution to some of these problems lies in international cooperation. This trend was proposed recently in an article in the Russian magazine NEWS by professor Kirill Stanyukovich, Moscow Bauman Institute of Technology; who states that space flight can be accomplished in the not too distant future "if the world's major scientific powers cooperate in developing and financing the project." However, the Soviets have a powerful 265,000 pound thrust engine, according to well-informed U.S. sources.

Incidentally, Stanyukovich said "calculations suggest that interplanetary craft will be in the form of atomic rockets. To overcome the pull of gravity, a 100-ton rocket would need 96 tons of conventional fuel. But since the tanks, the shell, and the control mechanism will obviously weigh more than 4 tons, this is not feasible. Chemical fuels cannot do the job. But nuclear fuels can. They can impart the required speed without involving such prohibitive loads. Thus a 100-ton rocket will need from 70 to 80 tons of inert propulsion agent, leaving 20 to 30 tons for effective load."



PROFESSOR I. P. BARDIN

it takes some thinking.

101st Airborne Division Gets Honest John Rocket

The first separate tactical unit of the Army to be armed with the 21-ton *Honest John* rocket developed at Redstone Arsenal, Huntsville, Alabama, is the recently reactivated 101st Airborne Division, based at Fort Campbell, Ky.

Named after the famous World War II outfit that distinguished itself in Holland and the Battle of the Bulge, the 101st is termed "the forerunner of divisions of the future."

Trimmed down to 11,500 men and discarding tanks and heavy equipment, the paratroopers of the 101st will serve as trouble shooters and can be completely airlifted on a few hours notice to any part of the world in only half the number of planes required for the 17,500 officers and men of present divisions.

The revamped division is composed of five combat groups of five rifle companies, each with supporting rocket artillery, instead of the conventional organization of three regiments with three battalions.

Recruiting Program Launched by Redstone

The Army's Redstone Arsenal at Huntsville, Ala., has set out resolutely upon the jungle trail that it, in common with most organizations dealing in aircraft, missiles and rockets, hopes will lead to the recruitment of capable young engineering graduates.

Restricted as it is by regulations that prevent a government agency from competing too directly with private industry, Redstone is slanting its engineering recruiting pitch toward only 20 young men who will be simultaneously accepting Army Ordnance Reserve commissions and receiving engineering degrees in the next few months from a handful of colleges.

To underscore the advantages of combining the required term of military service with a broad education in the intricacies of missile and rocket engineering, Redstone has produced a 28-minute color film that will be premiered tbis month before engineering students of LaFayette and Lehigh universities in Pennsylvania and shown later to interested students at those engineering schools whose Reserve Officer Training courses specialize in Ordnance and to other selected military colleges offering engineering courses.

Prospects are shown how they can combine military training with post-graduate instruction in missiles and rockets to become eligible for either continued military service in the field or for attractive Civil Service positions, with individual options for choice of specialties available at several points along the program.

Top Redstone Officials Attend Manpower Clinic

The deputy commander of the Army Ballistic Missile Agency, Huntsville, Ala., and two of the agency's top scientists represented the Army at a conference held Oct. 24 and 25 at the U.S. Naval Postgraduate School, Monterey, Calif., under auspicies of the International Science Foundation of San Francisco.

Brig. Gen. J. A. Barclay, Dr. Wernher von Braun, director of development operations, and Dr. Ernest Stuhlinger, director of the research project office, represented ABMA.

Washington Spotlight

By Henry T. Simmons

Fiscal 1958 looks like the big year for the guided missile. Key Pentagon officials report that a junior-sized "New Look" is now being taken at the nation's defense establishment in connection with the fiscal 1958 budget request. Key element in this appraisal is a determination by Missile Czar Eger V. Murphree of the extent missiles can replace aircraft, particularly in the tactical area. Watch for a reduction in the USAF goal of 137 wings of manned aircraft and greater reliance on such weapons as the USAF *Matador* and the Army *Corporal* and *Redstone.*

Government is taking significant interest in the principle of the rocket glider. The National Advisory Committee for Aeronautics is studying the idea, and this is usually a harbinger of military interest to follow. NACA believes a winged rocket vehicle could attain an appreciable fraction of orbital velocity at very high altitude, then use the aerodynamic lift of its wings to coast to its destination. Most likely military application: a globe-girdling bomber.

Big shakeout in the number of thermonuclear delivery vehicles now under development by the Air Force appears to be in the works. The airmen are developing eight separate systems—three aircraft and five missiles. They are the Convair B-58 bomber, the Boeing/North American WS-110A chemical bomber, the Convair/Lockheed WS-125A nuclear bomber, Northrop *Snark,* NAA *Navaho,* Douglas *Thor* IRBM and the Convair *Atlas* and Martin *Titan* ICBMs.

All of the new systems have technical merit, but the cost of developing them is staggering. Pentagon estimates a price tag of $200 million plus for each of the new systems, and this is too great an outlay for the USAF to carry. Therefore, it is virtually certain that some of the systems will be abandoned or "stretched out" in connection with the fiscal 1958 budget. Which will get the axe is the big question.

In the area of the ballistic missiles, the USAF development effort will certainly be reduced to two programs and possibly to a single program, depending on the progress of development. The *Atlas-Titan* effort will be narrowed to a single missile, while the *Thor* may give way to the Army's *Jupiter* IRBM. But it seems unlikely that any concentration will be undertaken in the ballistic field at this stage.

Missile Czar Murphree may move into the satellite field. Air Force interest in the so-called *Big Brother* (Air Force never revealed the true project name) satellite for gathering reconnaissance data is one force in that direction, but an even stronger persuasion may be the interest of satellite proponents outside the government in obtaining ICBM vehicles to launch earth-circlers up to 1000 pounds in weight. A moon-circling rocket using ICBM vehicles to reach escape velocity has been proposed.

Missile Training Schools Needed

Splendid cooperation between the Services has been experienced in the operation of our missile ranges, missile Czar Eger V. Murphree told a recent meeting of the American Management Association. "The management of a testing range in itself is quite a job," he said. "The range contains very complicated and normally quite new types of instrumentation which must be maintained and kept in good operating condition.

"In a case such as the one starting at Cape Canaveral, the range consists of a number of instrumented stations at rather remote locations," Murphree said. All ranges have much work to do and the most efficient schedule of this work is of utmost importance. Safety is quite a consideration since the missiles are experimental in nature and every precaution must be taken to see that any malfunction of the missile which may result in an explosion of considerable magnitude on or near the ground will not cause unavoidable damage to personnel or equipment.

"Before a launching of the missile can be made, the range, out from the launching point, must be cleared of people, vehicles or ships, as the case may be. The missile must be closely tracked and if it starts to deviate sufficiently from its prescribed course to approach the range boundaries, it must be destroyed."

MISSILE CZAR MURPHREE
Splendid cooperation between services.

Missiles, along with their ground equipment, in general represent really complicated equipment, Murphree emphasized. He mentioned the large numbers of electronic components involved. Because of their complexities, missiles pose real problems in regard to getting a high degree of reliability and also in training troops to use the missiles and to maintain them. It is not generally planned to carry out any real maintenance in the field, he said.

Field personnel will be provided with checking equipment of the "go-no go" type. If a component is indicated to be defective in the missile, it will simply be pulled out and a new component put in its place. The defective part will then be sent back to the manufacturer for repair.

Even with this simplification in maintenance procedures, the training problems are still of large magnitude and it is necessary to set up definite schools involving extensive training periods in order to get operational capability.

Type of management used by the Department of Defense in missile programs differs somewhat, depending on the type of missile involved, since a special management procedure has been set up for the long range ballistic missile program, Murphree explained.

For all types of missiles the basic responsibility for research, development, procurement, and use rests with the Services themselves; but because of the interrelationships of the various programs in the over-all national picture, progress is reviewed and guidance given by the Office of the Secretary of Defense.

IGY Satellite Experiments Named

First IGY satellite experiments have been revealed. They include: Cosmic Ray Observations (State University of Iowa); Satellite Environmental Measurements (pressure, temperature, meteoric incidence, skin erosion) (Naval Research Laboratories); Measurement of Solar Ultraviolet Intensity in the Lyman Alpha Region (Naval Research Laboratories); Measurement of Ionospheric Structure (Ballistics Research Laboratories, Aberdeen Proving Ground); Measurement of the Earth's Cloud Cover and Albedo (Signal Corps Engineering Laboratories); Measurement of Interplanetary Matter (Air Force Cambridge Research Center); Measurement of Meteoric Dust Erosion of Satellite Skin (University of Maryland); and Determination of Flux of Primary Cosmic Ray Nuclei with Atomic Number Larger than Eight (Research Institute for Advanced Study (Glenn L. Martin Co.) and Barton Research Foundation).

All of the above experiments are judged by the U.S. National Committee-IGY to be significant scientifically. First four experiments are in a more advanced state of development and are considered at this time to have the best expectancy for successful execution. All experiments continue under periodic review, and it is possible that some changes in the foregoing may be made. Several other proposed experiments are under active consideration. (See chart on page 120).

Record Attendance For ARS Meeting

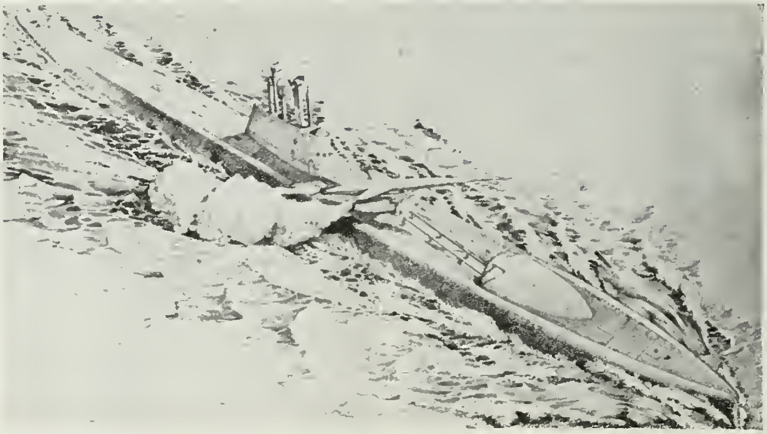
At press time American Rocket Society Secretary A. C. Slade could confirm to MISSILES & ROCKETS that a record crowd of between 1,500 and 1,600 had signed up for the Society's annual meeting. This is a substantial increase from last year's annual meeting, which had an attendance of 1,100. The ARS annual meeting will be held from Nov. 25-30 at the Henry Hudson Hotel in New York City.

Missile-Launching Subs Under Way

Navy's first real start towards tomorrow is this nuclear-powered missile-launching sub. With a length of 346 feet and a beam of 29 feet, this vehicle has been requested as part of the Navy's 1957 construction program. By comparison with what is planned to follow, it is but a primitive beginning. Last summer, under the auspices of the Office of Naval Research, a three months-long conference was held at Woods Hole, Mass. There, day after day, Navy scientists and strategists were host to a steady stream of the finest brains in industry. Unknown to the thousands of tourists vacationing on Cape Cod and nearby Martha's Vineyard, these men were reshaping the Navy to fit the concept of a world of nuclear power, missiles and rockets. Everything was welcomed and considered from blue-prints and top secret data books to dream and off-chance ideas. From this meeting, the rate and pattern of development of the Navy for the next decade was charted.

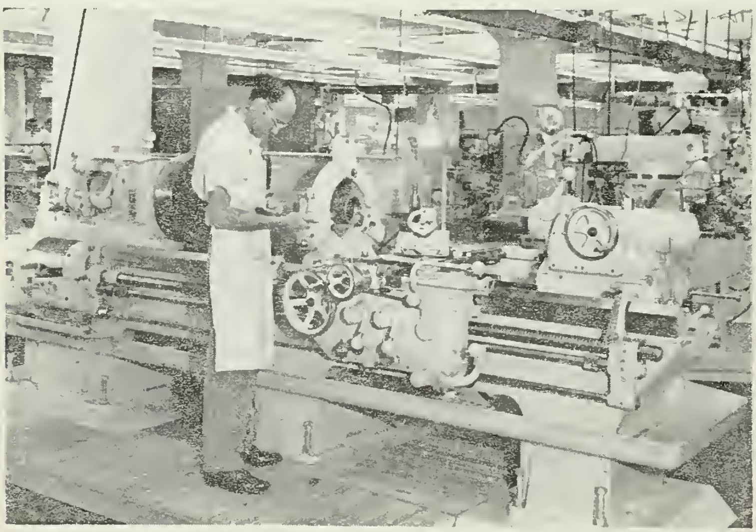
The artist's drawing of the proposed submarine is a close rendering of the vessel to be. The missile itself probably comes more from the artist's than the missile engineer's mind. But this much is known. First models will be guided by the sub. This surface-to-air guidance system already has been worked out. The missile itself, is surface-to-surface.

After this concept will come the underwater-to-surface long range guided missile—launched from a mother sub well under the surface, it will then break through into the atmosphere and proceed to perform like a conventional ballistic or super glide missile.



Artist's drawing of proposed nuclear submarine is said to be close rendering of the vessel to be. Missile will be guided from the submarine against surface or air targets; system already has been worked out.

Building the ICBM nose cone prototype



General Electric's Missile and Ordnance Systems Department has completed setting-up of an ultra-modern machine shop in its headquarters building in Philadelphia. Conducting model and prototype work on Atlas ICBM nose cone, MOSD's machine shop will be moved to facilities at Valley Forge, Pa., in 1958.

$50 Million For BuAer Avionics

Major change in the recent reorganization of the Research and Development Dept. of the Bureau of Aeronautics is the formation of a new Avionics Division with a commitment budget of $50,000,000, consisting of three major staff branches and four line branches. Avionics will be under the direction of Capt. W. E. Sweeney, USN, and will be responsible for all avionics and astronics gear for aircraft and missiles used in locating targets, maneuvering for attack and delivery of the weapon.

$5 Million For Army Missile School

A $5,000,000 program to provide additional buildings and equipment for the Army Ordnance Guided Missile School, Redstone Arsenal, Huntsville, Ala., is nearing final approval and should be started in the near future, it is learned.

Already the size of a small college with two-score buildings, 400 students and a faculty of 40, the Guided Missile School will be expanded to provide study facilities, housing and equipment for detailed instruction in several new missile weapons systems.

Since the first class was graduated in 1952, the school has trained more than 5,000 Army officers, enlisted men and key Civil Service personnel assigned to missiles work.

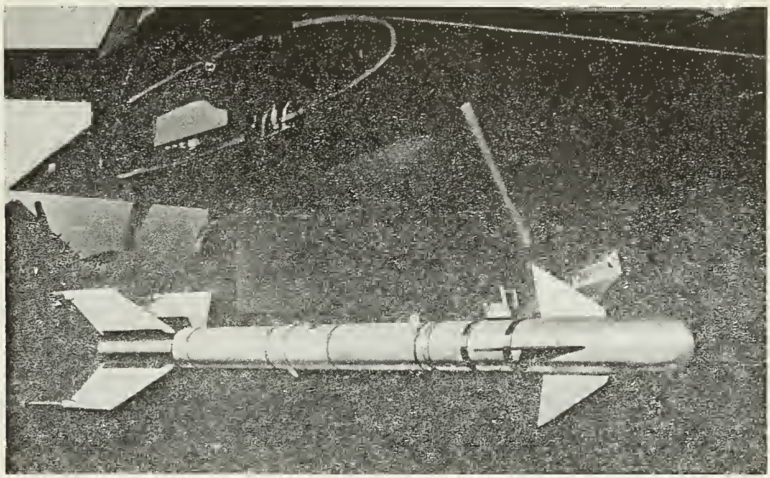
Sidewinders for U.S. Air Force' F-104?

Small and light enough to be carried in quantity by single-seat interceptor planes, the Navy's new *Sidewinder* may be fired singly or in salvos. *Sidewinder* requires no complex launching equipment but is fully maneuverable at supersonic speeds. It has an unusually high single-shot "kill" reliability. Air Force is believed to be considering *Sidewinder* for the F-104.

Although details on the missile's guidance system have not been disclosed, the Navy says *Sidewinder* requires no special pilot training. It may be launched well beyond reach of an enemy aircraft's defense.

Philco's Government and Industrial Division which played an important role in assisting the Naval Ordnance Test Station, China Lake, California, in the research and development program of *Sidewinder*, is now manufacturing the missile and has begun scheduled deliveries.

Sidewinder is basically a defensive weapon and will be used to augment the protection of our men and ships at sea from attacks by enemy aircraft, thereby enhancing the position of the fleet in maintaining freedom of the seas for all nations. *Sidewinder* also will be employed in air defense of the continental United States.



SIDEWINDER heat-seaker bird can change its course to account for tactical movement of an enemy target. Although time of interception is very short, SIDEWINDER has displayed extreme deadliness during recent tests.

Oh Deer! Redstone Cattle Are Contented—and Clear

Several thousand cows and sheep at Redstone Arsenal enjoy privileges denied to most of the 50,000 inhabitants of nearby Huntsville, Ala. They can rove at will through some of the nation's most closely guarded rocket and missile territory under an arrangement whereby grazing and haying rights are leased on 16,000 of the Arsenal's sprawling 41,000 acres. The Alabama quadrupeds have developed instincts similar to those of the many wild deer at Aberdeen, Md., Proving Ground which thoughtfully absent themselves as regular firings begin each afternoon. The Redstone livestock noticeably make tracks when missiles and rockets are brought out to test stands for firing.

NEW RADIOPLANE TARGET MISSILE

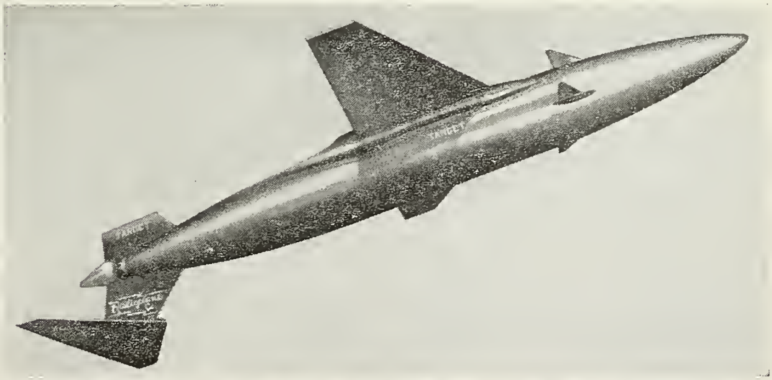
Powered By Solid Rocket

Radioplane Company has announced the development of a new rocket powered target drone series designated the RP-70 type. Designed for weapon system evaluation and training in the Mach 0.9 class at 50,000 feet, the RP-70 is powered by a solid-propellant rocket with a flight endurance of eight to ten minutes.

Airframe, weighing 300 pounds, is specifically designed for high volume production. It is slightly over nine feet in length with a wing span of five feet. With the exception of the steel rocket motor case, which makes up the mid section of the fuselage, all other primary structures are made of glass fiber and plastic.

The plastic wings, horizontal and vertical stabilizers are fixed surfaces. Control of the drone is accomplished by small canard-type vanes located just forward of the wing and linked directly to the flight control system.

Payload capabilities are sufficient to accommodate the special tracking and scoring equipment required by the Armed Services in training, evaluation and the development of tactics for their various defense missile systems.



RP-70 target drone missile built by Radioplane Company can operate at altitudes as high as 50,000 feet; flight endurance is eight to ten minutes. Solid rocket gives the bird Mach 0.9 velocity.

World Astronautics

By Frederick I. Ordway, III

The Brooks and Perkins Co. of Detroit will perhaps be making the Vanguard IGY satellite sphere in quantities up to 35. Smaller satellites of 6 or 12 inch diameters may be constructed in addition to the planned 20-inch variety. Skin thickness of the larger ones will be 0.03 inches, a third greater than originally contemplated. The shell will weigh about 4 pounds and will be made as follows: Magnesium, 95%; Aluminum, 3-3½%; and Zinc about 1%. Interior bracing will be provided by magnesium tubing and Kel-F low thermo-conductivity plastic.

There has been some talk about an "expanding satellite" which, upon entering orbit, would increase in size. Fired along with conventional types, it would hold the same orbit for a certain period of time. Because of its larger size, however, its orbit would slowly decay to circularity and finally the satellite would enter the dense atmosphere and be destroyed. Comparing the orbital characteristic of conventional and "expanded" satellites, scientists would find data on conditions at extreme altitudes, particularly on densities.

Broadcasts from Moscow hint at coming Russian moon rockets. It is known that a specific moon rocket study has been completed, and that the Russian scientists plan on launching satellites during the IGY.

We are to have spaceship plays, or so we are told in an article in the *New York Times.* Arch Obeler's "Night of the Auk" will reach Broadway next month with an all-male cast. In it we shall learn all about the "troubles that beset the first spaceship to be launched from earth to the moon."

Some interesting items on the Mars studies include: (1) polar caps seem to be evaporating more rapidly than usual, (2) violent sandstorms are in evidence, about 3,000 miles long, (3) a 50-mile diameter bright spot was discovered, (4) Mars, at closest approach, has a lemon-color rather than a characteristic orange-red color, (5) a violet halo or veil appeared to surround the planet, (6) this violet was accompanied by a yellowish haze, (7) as planet moved away from Earth, color seemed redder than usual, (8) due to reduced reflectivity of atmosphere, the planet seemed fainter than usual, (9) like Venus and Jupiter Mars emits radio signals, and (10) Naval Research Laboratory reports indicate temperature readings average just below the freezing point of water on Earth. Mars, apparently satisfied that Earthlings still have a long way to go before landing on its surface, moved outward into space as September closed.

Operation Tan Glove will be of help to satellite geomagnetic studies. A KC-97, carrying a 1500 pound cosmic ray monitor is taking an irregular circum-terrestrial trip to determine the Earth's magnetic field at high altitudes.

Redstone Quantity Production Started

Production of *Redstone* missiles for Army Ordnance is in full swing at Chrysler Corporation, Detroit. Announcement that the medium-range missile is to become operational shortly is expected soon. First battalion is being readied now.

Officer Training Course

The Ordnance Corps' most advanced class of officer trainees has concluded a one-week course of study at the Ordnance Guided Missile School, Redstone Arsenal, Huntsville, Ala. This is the first time that such a class has received on-site instruction at the huge missile and rocket development center and is thought to foreshadow regular instruction here for succeeding classes in the Ordnance Officer Advance Course of 30 weeks at Aberdeen Proving Ground, Md.

Seven members of the staff and faculty of the Ordnance School accompanied 47 student captains and majors for instruction at Redstone. The group received detailed training on the *Nike I & B*, the *Redstone*, the *Corporal II, Hawk, Dart* and *Lacrosse* missiles, worked at the Army Ballistic Missile Agency test ranges and studied work in progress at the highly secret Fabrication Laboratories.

Reliable Weapon

The *Redstone* missile is termed "rugged" in that it has been designed for rough handling and for typical GI surface transportation and environment. Army missile authorities have praised Chrysler Corporation in its effort to make the *Redstone* a most reliable weapon in spite of the fantastic amount of complex systems and wiring that go into this type weapon.

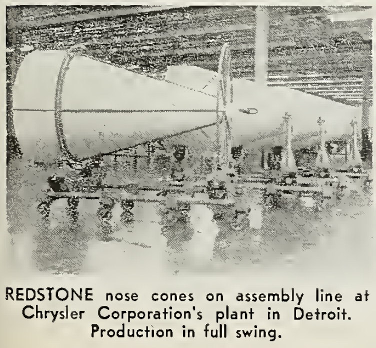
Missile-Carrying Satellite

Dr. Wernher von Braun, development operations chief of the Army Ballistic Missile Agency, suggested the possibility of launching a satellite station into outer space during a talk to the Association of the Army at the Sheraton-Park Hotel, Washington, D. C. Photo indicates the orbit of such a satellite station around the earth. The inner arc is the trajectory of a guided missile which could be directed by the crew of the satellite directing it. At the speed of missile and satellite, the missile would traverse a distance equal to three-fourths of the earth's circumference. It would be under control of the satellite station crew at all times.

Chrysler Corporation cannot reveal its production output for *Redstones;* nor will DOD or the Army tell anything about how much money is being allocated for the program. Says one Army spokesman: "For obvious security reasons, the American public simply must accept the fact that we've got a missile that's really hot—and it's being mass produced."

The *Redstone* missile has been termed the most potent current U.S. missile. The *Redstone* rocket engine, built by North American, yields a thrust of 75,000 pounds and is considered the most proven U.S. liquid rocket.

The *Jupiter,* in the meantime, "is definitely and certainly on time; each milestone fixed a year ago is being met, and some guide posts are being surpassed," declared Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency at the recent Army Association's Annual Meeting in Washington, D. C. Even so, and since the *Jupiter* could not possibly become operational for another two or three years, the *Redstone* will continue to be the Army's big-punch weapon for some time to come.



REDSTONE nose cones on assembly line at Chrysler Corporation's plant in Detroit. Production in full swing.

Wrapping-up of REDSTONE control section at the factory. Most REDSTONE missiles are shipped to Huntsville by truck.

Huge missile is transported on special dollies; weapon is designed to take rough handling and transportation.

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missiles and rockets

OUTSTANDING ARMY ROCKET RECORD

A spectacular new distance record for rocket flight was racked up by Army scientists in September when a three-stage *Redstone* assembly was fired from Patrick AFB, Fla., 3,000 miles into the South Atlantic.

The new range and altitude marks represent convincing proof of the Army's progress in its all-out drive to develop the *Jupiter* before the U.S. Air Force can get its competing *Thor* IRBM into shape. Both services are working out IRBM versions with the understanding that only one will be ordered into production. Preliminary tests on the *Thor* are scheduled at Patrick next month.

Here are the components of the record-setting vehicle:

First stage was a standard *Redstone* rocket, which employs a mixture of liquid oxygen and alcohol for combustion. North American Aviation, Inc., supplies the rocket motor, while Chrysler Corp. manufactures the 69-foot airframe.

Second stage of the vehicle consisted of a cluster of solid propellant rockets, while the third stage was a single solid-propellant rocket of the same type. They were said to resemble the *Recruit*, a scaled-down version of the *Sergeant*. Both rockets were designed by the Jet Propulsion Laboratory of California Institute of Technology and are produced by the Thiokol Chemical Corp.

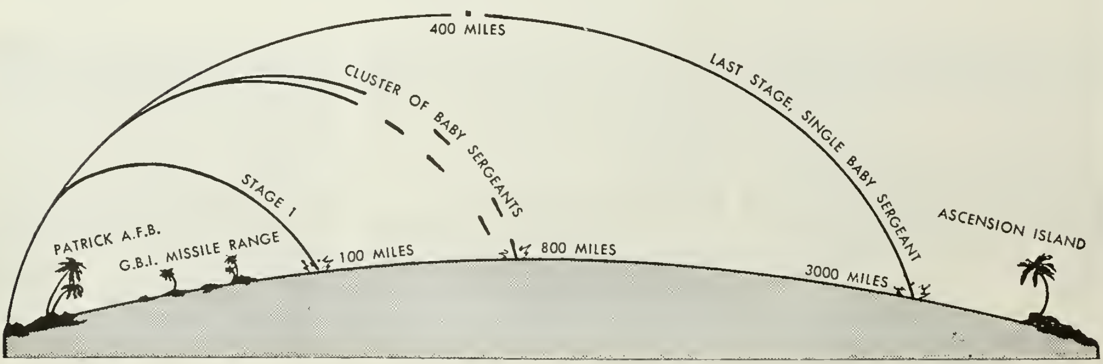
Here's how the test vehicle worked in flight:

The *Redstone*, which normally has a range of more than 200 miles, burned out, separated and fell into the sea approximately 100 miles from Patrick. The second stage cluster exhausted itself and fell into the sea about 800 miles from the launching site. The final stage coasted to an altitude of 400 miles after burnout, then fell into the South Atlantic at a point 3,000 miles from Patrick.

It is interesting to note that the final stage of the vehicle encountered something of a re-entry problem on its downward trip through the atmosphere. It evidently surmounted the effects of aerodynamic heating, however, because it managed to fall into the sea without burning up.

The significance of the range achieved by the *Redstone* assembly is not merely the fact that it is a new record. The Army's ability to shoot a rocket 3,000 miles was forecast last spring by Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency at Redstone Arsenal.

But he also said the Army could do much better. In testimony before the Symington airpower subcommittee, he declared: "By no great stretch 5,000 miles could be achieved."



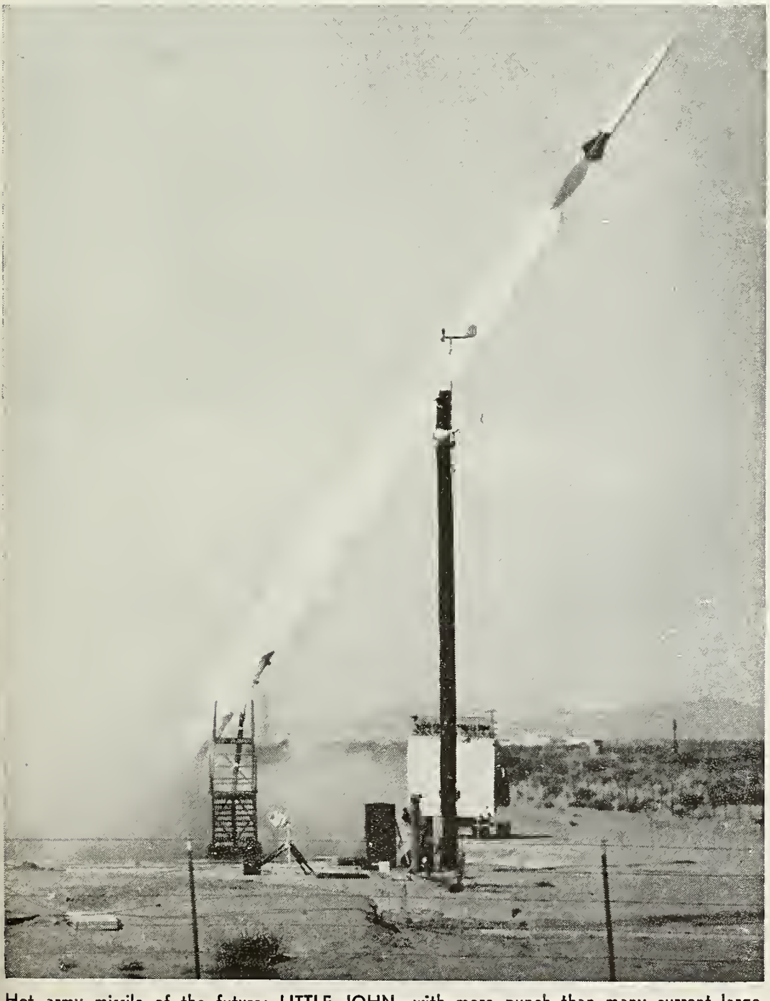
ARMY missiles of *TOMORROW*

UNITED STATES Army has some hot missile projects in the works. And some of these will be operational within months, while the more sophisticated weapons—the anti-missile missiles—are in their early stages.

Next four Army missiles to be included in the current weapons arsenal are the *Redstone, Little John, Dart,* and *Lacrosse.* According to Wilber M. Brucker, Secretary of the Army, *Redstone* development is so advanced that Army units will be equipped with this missile shortly.

"The Army's arsenal must continue to be stocked with a well balanced variety of weapons, each fully adapted to a particular function, and each the best of its kind that modern technology can provide," the Army Secretary said.

Other advanced Army missiles include the *Little John* and the *Dart.*



Hot army missile of the future: LITTLE JOHN—with more punch than many current large-size weapons.

For Redstone's 400-man Rocket Development Laboratories, *Little John* was a manifold triumph. The 12½ inch, 318-millimeter rocket, about 12 feet long and packing the explosive power of heavy artillery, was successfully produced and demonstrated in a crash program that started only last February. It was test fired in June, only a matter of months after initiation.

Redstone's experts term *Little John* the second "unconventional weapon"—i. e., one not dating from World War II—to be considered for the Army's missile arsenal. The first was the *Honest John* rocket, initially fired in August, 1951, and now in the hands of U.S. troops in this country and abroad. *Honest John* represented the need for a free flight rocket artillery weapon with high accuracy, simplicity of design and operation, extremely high mobility, no electronic controls and a range equivalent to medium to long range artillery. It weighs several tons and is about 37 feet long.

The dimensions of *Little John* are about one-third and its weight one-sixth that of its predecessor. It can be carried in a helicopter.

Little John thus represents perhaps the growth of a new family of rocket weapons that ease logistical problems and give Army field commanders a wider choice of warheads for use against combat targets.

Little John recently was demonstrated to ordnance experts at Aberdeen in a driving rain storm, showing its all-weather capabilities and achieving a "remarkable accuracy on target."

For another, it was determined that if the Rocket Development Laboratories, a part of Redstone's Ordnance Missile Laboratories, directed by Col. Miles B. Chatfield, conducted the *Little John* program, as though they themselves were the prime contractor, they would thus acquire invaluable experience in the painstak-

ing coordination essential to development and manufacture of today's complex weapons systems.

Under the direction of OCO (Office, Chief of Ordnance), the task force itself provided the necessary research and development work and guidance in design control, aerodynamics, metal parts and powerplant. The Allegany Ballistics Laboratory at Cumberland, Md., supplied propellants. Powerplant metal parts were fabricated by Consolidated Western Steel of Los Angeles. Emerson Electric of St. Louis manufactured the air frame. Army Ordnance's Rock Island Arsenal, Ill. provided the launchers. Proof testing was assigned to White Sands Proving Ground, N. M. and by Redstone's own staff. Warheads came from the Army's Picatinny Arsenal at Dover, New Jersey.

First firing tests that saw the *Little John* prototypes burying themselves in the sands of White Sands Proving Ground thus represented careful coordination of effort. Since the production of *Little John* is conducted at Redstone, the Army is able to exercise detailed supervision over all phases of manufacture.

Maj. Gen. H. N. Toftoy, Redstone commander, said the new rocket "should prove to be very important in the Army's new mobile 'fire brigade' concept in the air age."

Details revealed about the anti-tank *Dart* missile indicate it is "a simple but effective weapon" approximately five feet long with a configuration characterized by fins crossing its waistline. Started in 1953 *Dart* was developed by Aerophysics Corp. of Santa Barbara, Calif., under Redstone Arsenal supervision.

Missiles such as the *Redstone*, *Little John* and *Dart* are forerunners for some truly sophisticated weapons now being studied intensively by the Army, yet these missiles are rather indicative of the Army's missile power potential for the next few years. Under development are anti-missile missiles and long-range ballistic missiles—the latter will have pin-point accuracy and a striking range of several thousand miles. The anti-missile missiles will be designed to knock any enemy guided weapon out of the sky, a truly formidable engineering task. But missile experts and Army authorities believe it can be done.


Army anti-tank DART missile zooms away towards target. At recent public demonstration at Aberdeen Proving Ground DART made impressive bullseye hit at small target over 2100 yards distance. Quantity production is now under way.


DART is wire-guided, praised for simplicity, accuracy and ease of handling. Design is based on German and French concepts; Germans used wire-guided missiles in the last war.

GI training program for DART familiarization is underway. DART will be operational soon.

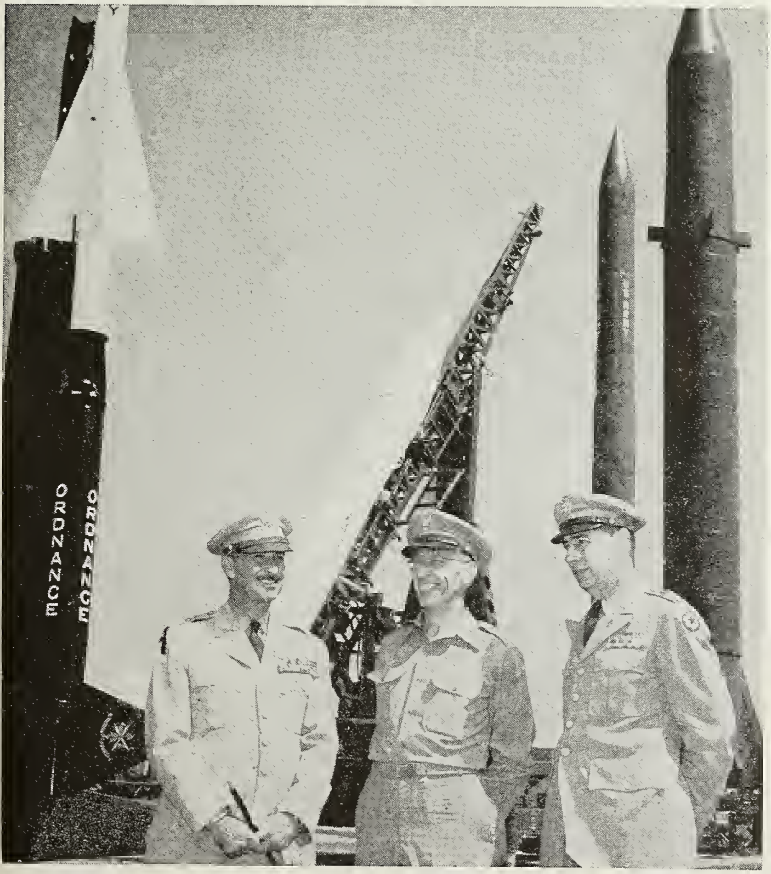
ARMY'S role in guided missiles

• Progressive New Guided Weapons Program

By Major General H. N. Toftoy

STATE of the art indicates that guided missiles will, in the near future, be able to reach any place on the surface of the earth with reasonable accuracy and reliability. Today, guided missiles, incorporating different combinations of propulsion, guidance, and warheads, are available for various tactical, strategic, and air-defense uses.

This is truly amazing progress when it is considered that only 15 years ago, when the Japanese attacked Pearl Harbor, the United States did not have a single service rocket or guided missile.



Army missile leaders pose in front of Nike, Honest John, Corporal and Redstone rockets. From left to right, MAJ. GEN. JOHN B. MEDARIS, commanding general, Army Ballistic Missile Agency; MAJ GEN. H. N. TOFTOY, commanding general, Redstone Arsenal; and COLONEL HENRY S. NEWHALL, commandant, Ordnance Guided Missile School.

It is a tribute to the determination of the Armed Forces, the imagination of the scientists and the ingenuity of industry that there now are many successful missile weapons in operation. And the Army has played a leading role in the nation's overall program.

For centuries wars were fought on land and on the sea. Then, in a relatively few years, man's ingenuity extended the elements of warfare under the sea and into the air and thereby created new factors to be reckoned with in determining the strategy and tactics necessary for victory. These new elements, along with technological advances, have greatly altered the scope and nature of conducting war—but they have not changed its basic nature. Sea and air power are essential components of our military strength. The nation could not survive without them any more than it could survive without adequate land forces. To debate which armed service is the most important is nonsensical.

One kind of power may temporarily become more important than another during certain stages of a war, but in the overall consideration, they are all equally important. They are not, however, equally decisive. It is the fighting man with his feet on the ground and armed with superior weapons who defeats the enemy's ground force, seizes his land, and holds it. These are the climactic actions which cause the enemy to decide that resistance cannot continue.

Nevertheless, the sea and air forces contribute indispensable operations before and during such actions.

Our national security, then, depends on the proper teamwork of a combination of combat-ready forces from all the services. The United States Army, capable of winning land battles and controlling land areas, is the final and decisive element of United States military power.

It is obvious that the development of new weapons is bound to change the manner an Army carries out its missions of ground combat. Through the ages there has been a gradual evolution of military science, but modern technology has expedited this evolution.

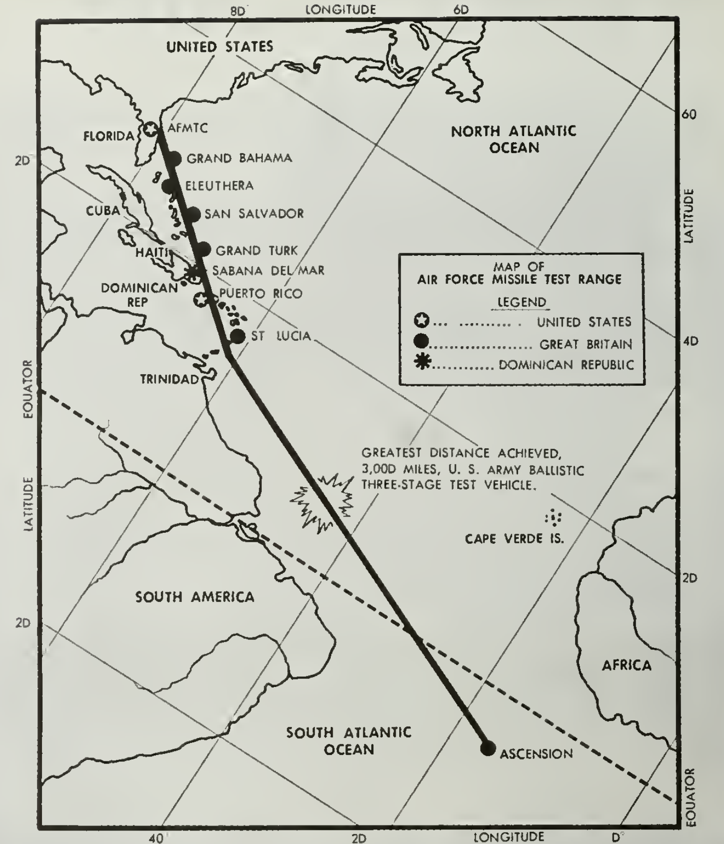
Our Army is keeping abreast of changing conditions by continually evaluating new weapons and techniques and adopting those weapons (new, old, or combinations thereof) which best meet the requirements of its missions.

Atomic Warfare

The Army requirements for supersonic surface-to-surface missiles also came about by changing conditions. The range and firepower of conventional guns were being outstripped by greater mobility and the more "fluid" tactics of modern warfare. The use of atomic weapons in land warfare has forced greater dispersal of ground troops and created much wider and deeper combat zones.

No longer are there clearly defined lines between battle and support zones. A ground commander must be capable of supporting his operations by atomic firepower having a wide variety of ranges and yields—short range for assault and demolition, medium range for supplementing and extending his artillery, and range capable of supporting deep penetrations and airborne operations.

As was experienced during the battle of the Bulge, tactical support aircraft were too often hampered by adverse weather; they were not the answer. What the Army needs is a family of all-weather, supersonic guided missiles which can be used effectively, day or night, and without air superiority, and against which there are no known countermeasures.



That, in brief, is the reasoning behind the Army's expanding guided missile program.

When the Army guided missile program was initiated in 1943 it was realized this would involve pioneering in a field new to U.S. technology. A long range program was carefully planned and included the necessary research to provide the basic knowledge required for the successful development of supersonic guided missiles. At that time little was known about supersonic aerodynamics, the sound barrier, thermal barriers, or the environment of flight. Man's fundamental scientific knowledge had to be quickly extended.

The Ordnance Corps was assigned the cognizance of developing and producing the Army's guided missiles. It was well qualified, having had years of aerodynamic and ballistic work with projectiles and long experience with complex fire control systems.

Recognizing the technical complexity of the development problems and the need for utilizing the best talent in the country, the Army Ordnance Corps early established a policy of contracting an entire weapon system with the most capable civilian scientific and industrial organizations available.

In 1943 the Jet Propulsion Laboratories, operated by California Institute of Technology, and the Ballistic Research Laboratories each was requested to investigate the feasibility of developing ballistic type guided missiles. Impressed by the favorable reports from these studies, Ordnance placed the oldest of its contracts with JPL for research on guided missiles, with emphasis on rocket propulsion and supersonic aerodynamics.

In less than a year, two more contracts were negotiated. These established the *Hermes* project of broad scope for the development of missile weapons with the Gen-

eral Electric Company and the *Nike* project with the Bell Telephone Laboratories of the Western Electric Company for all the necessary work required to develop an anti-aircraft missile system. Douglas Aircraft Company, although a sub-contractor, was a full partner in this effort.

As the program developed, many other industrial firms, educational institutions, and research organizations became members of the Army team of contractors. Special facilities were required before much progress could be made.

Long-range Concept

The Army, from the beginning, was thinking in terms of guided missiles having ranges of 1000 miles or more. In fact, the original program included preliminary work on a proposed 500-mile missile. It was apparent that a proving ground having a test range much longer than any previously conceived would have to be provided.

In order to obtain technical data pertaining to flight tests, it would also be necessary to devise and install a complex system of range instrumentation. Since it was important to recover spent missiles for study, an overland test range was decided on. Accordingly, White Sands Proving Ground in the New Mexico desert was authorized in 1944. Being the only overland guided missile range in the country, this Ordnance Corps facility is jointly used.

Thus having established projects with highly qualified contractors, and provided them the necessary tools-of-the-trade and proving ground service, the Army was, by 1945, seriously engaged in the guided missile business.

The Ordnance Corps also recognized the achievements of the German V-2 scientists and engineers. They were the most experienced ballistic missile group in the world, and the American program could profit by their specialized technical knowledge. Accordingly an integrated team of 130 key specialists was selected and brought to Fort Bliss, Texas. There they were organized to conduct studies and perform development work on medium range guided missiles, translate captured documents, and assist with the assembly and firing of V-2's at White Sands.

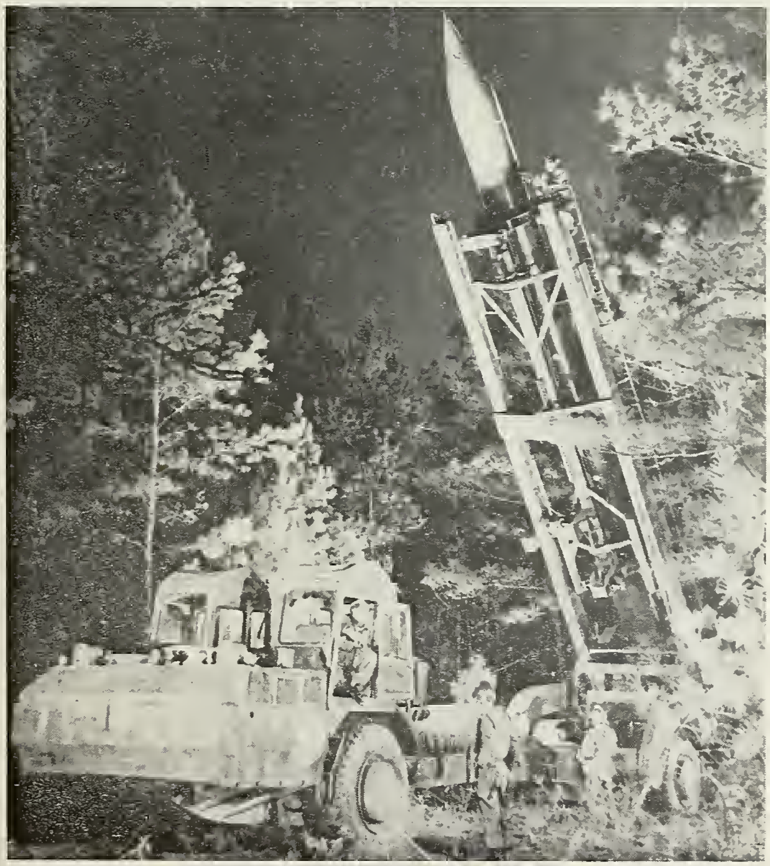
The German scientists were extremely cooperative and provided technical information of interest to all agencies engaged in the National program. They were later transferred to Redstone Arsenal where their work has been outstanding, and they have become highly respected citizens of their community and of the United States.

Rapid technological progress was made from the beginning. Information of importance to missile designers was being developed at the various projects and distributed to all interested agencies.

Out of the many early rocket programs emerged the Army's present operational missiles. *Nike*, the first operational and extremely effective air defense guided missile, is being used to protect this country's most important cities and industrial areas. *Corporal*, the faster than sound surface-to-surface guided missile, and the *Honest John* rocket have provided our ground forces, in the United States and overseas, unprecedented firepower.

Other missiles, including the longer range *Redstone*, the IRBM *Jupiter*, the anti-tank *Dart*, and the more advanced anti-aircraft missiles are well on the way to taking their places in this Nation's arsenal of truly modern weapons.

By 1949 the program had grown to the extent it became necessary to decentralize its management from the Pentagon to a field installation. For this purpose Redstone Arsenal was designated the permanent Ordnance Corps commodity arsenal for rockets and guided missiles and assigned the responsibility of conducting the

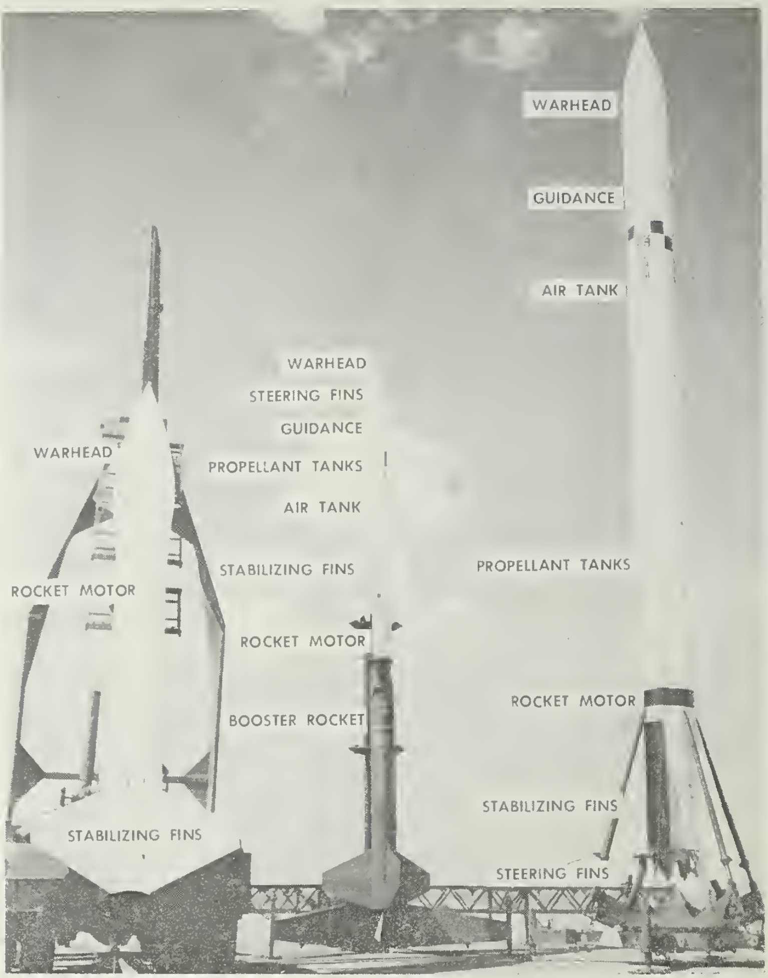


Army Corporal guided missile in typical tactical position with personnel of 601st Field Artillery Missile Battalion. Versatility of this missile is indicated by the fact that GIs now operate Corporal weapons system at night and under all weather conditions. Corporal is in service here and abroad, substantiating U.S. Army's atomic striking capabilities.

nationwide Ordnance activities in this field. The Ordnance Missile Laboratories, which performs research and development on solid propellants, rockets and guided missiles, and the Ordnance Guided Missile School, which trains personnel in missile maintenance, were also established at Redstone.

The arsenal built up highly competent groups which carry assigned rocket or guided missile projects through from preliminary design to final test—then manage the procurement and the storage, issue and maintenance of these weapon systems, as well as conduct the Ordnance training in this field. In addition, important research and development work is being performed in the arsenal laboratories on solid propellants and their application by two contractors—The Thiokol Chemical Corporation and the Rohm and Haas Company.

The integration of the former German scientists into its organization gave Redstone Arsenal a uniquely qualified and experienced guided missile team. The Guided Missile Development Division, under Dr. Wernher von Braun, drew nationwide recognition for its competence in developing the *Redstone* missile. In February 1956 the personnel and facilities of this division were transferred to the new Army Ballistic Missile Agency, specifically established for the expedited prosecution of a program to place the intermediate range ballistic missile, *Jupiter*, and the shorter range *Redstone* in operational status as rapidly as possible.



Honest John, Nike and Corporal missiles represent Army's family of operational missiles; Little John, Dart and Redstone soon will be included.

While the three services have conducted separate guided missile programs suited to their individual needs, there has been a full free exchange of technical information, and excellent cooperation between the various projects of the Army, Navy and Air Force. The Army, for instance, developed and produced rocket motors used on the Air Force's air-to-air missile, FALCON, and booster rockets for its MATADOR, and in turn used an Air Force power plant for its REDSTONE missile. A Navy solid propellant was used in the Army's HONEST JOHN rocket.

In an interesting experiment in 1947 the Army cooperated with the Navy in firing a V-2 from the deck of the U. S. S. Midway, and proved that large ballistic missiles could be successfully launched from ships at sea.

Among its contributions to the national program was the Army's pioneering work in connection with an earth satellite program. Ordnance personnel at Redstone Arsenal made extensive studies into the problems involved and was largely responsible for establishing the feasibility and laying the groundwork for the current U. S. satellite project recently initiated under the cognizance of the Navy.

We can all be proud of the achievements of the Ordnance-Science-Industry team which pioneered in the art of rocketry and produced this country's first supersonic guided missile weapons in a relatively short period of time.

The Army is proud of the performance of its missile weapons, and the public would be too, if the facts could be disclosed without jeopardy to the security of our nation. The frontiers of science are being pushed ahead at an unprecedented rate. The Army is continuing a progressive program on a new family of guided missiles which will better meet the various military requirements imposed by modern warfare.

The future presents an exciting challenge—and we of the Army look forward to it with great anticipation. The development of guided missiles, especially when combined with the progress in atomic weapons, is a tremendous step toward a truly modern Army ready to contribute a formidable defense to the free world. END.

ARMY'S missile arsenal today

Three versatile high-power missile systems are in actual operation with the U.S. Army. They have helped streamline our defense on a global basis. While waiting for newer weapons,* Honest John, Nike *and* Corporal *form the core of the GI missile arsenal.

By Captain Patrick W. Powers

THE U.S. Army now flexes its missile weapons system for the defense of Europe as well as the defense of the continental United States. In Germany's Black Forest farmers often have witnessed a *Corporal* missile battalion occupying a position during a tactical maneuver designed to strengthen the NATO defenses of Europe.

At the same time, on the outskirts of Chicago, radars of the Army's third operational missile system—the *Nike I*—track high flying jet aircraft on practice runs designed to sharpen the missile battery's twenty-four hour alert status. In a world-wide glance at our country's defenses we see that missiles are taking an active part.

The three systems mentioned are operational now—ready for hostilities. They have been organized into conventional-sized artillery organizations and operate with the same traditions of efficiency and confidence. To maintain a high level of proficiency they continually train and are integrated with the other conventional weapons of war.

Honest John System

This missile system is composed of the missile, a self-propelled launcher and an anemometer to measure the speed of the surface winds. The rocket is approximately 27 feet in length and 30 inches in diameter. It consists essentially of a warhead and the solid-propellant rocket motor with large tail surfaces for flight stability. The launcher is a movable, 25-foot rail mounted on the chassis of a regulation Army truck. The wind determining equipment is pole-mounted to register the velocity of the surface winds that effect the initial flight of the missile.

Honest John ballistic rocket roars aloft from White Sands Proving Ground.

The *Honest John's* trajectory to the target is determined by the elevation and azimuth of the launcher prior to firing. The effect of the direction and speed of the surface wind at firing is considered in a final setting of the launcher. The missile is fired remotely by an electrical signal that initiates the burning of the solid propellant. As the rocket leaves the launcher a slow spin is imparted to it by small spin rockets which give a more stabilizing effect to the trajectory.

After a few seconds of powered flight, the *Honest John* assumes a free-flight or ballistic trajectory to the target. Finally, the warhead system detonates the warhead at the target. Here, in reality, is the baby brother to the mighty 1500 mile ballistic missile—*Jupiter*—that the Army is now developing.

Nike System

It is a long technological jump from unguided rocket to the *Nike* system and its vast complexity. The system consists essentially of a two-stage missile and elaborate control equipment requiring approximately 1,500,000 separate parts. The *Nike I* is about 20 feet long and one foot in diameter with two sets of

fins for guidance and steering. Its weight is more than one-half ton.

Inside the *Nike* are an explosive warhead, a guidance unit, and a propulsion system consisting of two propellant tanks, an air tank, and a rocket motor. When the missile takes off, the initial seconds of flight straight up are powered by the solid propellant booster rocket which drops off before the *Nike* turns and heads for the target at a supersonic speed. After the booster falls away the missile's own rocket motor begins to generate power and the second stage of the trajectory begins.

Control equipment consists mainly of three radars, an electronic computer, and automatic plotting boards. This is the combination of intelligence that detects approaching enemy aircraft and directs the *Nike* to the spot in space where they will meet and the warhead will be detonated.

First of the radars, the acquisition radar, detects a target aircraft at long range and alerts the battery control area. A second radar, called the target tracking radar, picks up the aircraft at a closer range. Then this information of the target's position and speed is continually fed to an electronic computer whose job is to keep track of the target and the missile, when launched, so that it can determine the commands to be sent for optimum interception.

In the meantime, the third radar which follows the missile supplies information on the *Nike's* position to the computer. Commands to direct the flight are determined by the computer and transmitted to the missile's guidance components which in turn cause the steering fins to move in the proper direction and the proper amount. Any evasive action by the target is instantly detected by the target-tracking radar and transmitted to the computer. The computer re-evaluates the trajectory of the missile to meet this new change of direction of the target and appropriate steering signals are transmitted to the *Nike*.

All of this happens—automatically measured—in thousandths of a second. The entire operation from determining the changes in the aircraft's flight path to the receipt of

U. S. Army Missile Arsenal

Type	Manufacturer	Powerplant	Remarks
		Surface-to-Surface	
REDSTONE	Chrysler	North American liquid rocket	Can carry atomic warhead.
JUPITER	Chrysler	North American liquid rocket-booster	IRBM weapon; derived from Redstone.
HONEST JOHN	Douglas/Emerson	Hercules solid rocket	In service; unguided artillery rocket.
LITTLE JOHN	Douglas/Emerson	Hercules solid rocket	In operation soon.
SERGEANT	Redstone Arsenal (?)	Solid rocket	In operation.
CORPORAL E SSM-A-17	Firestone	Liquid rocket (Jet Propulsion Laboratory)	Gilfillan beam guidance; also Corporal F; in production and in service.
DART	Aerophysics Development	Solid rocket	Wire guidance; anti-tank.
LACROSSE	Martin	Thiokel solid rocket	Anti-pill box; Marine Corps interested.
		Surface-to-Air	
TALOS L	Bendix/-McDonnell	McDonnell ramjet—booster	In production.
LOKI	Bendix	Solid rocket	In production.
NIKE SAM-N-7 NIKE B	Douglas/Western Electric	Aerojet liquid rocket — solid rocket booster	In service, also overseas; Nike B is a slightly larger more effective version.
HAWK-SAM	Raytheon	Liquid rocket	Production begun.
SHRIKE	?	Liquid rocket	Nuclear warhead.

the steering commands for intercept by the missile are accomplished electronically.

Corporal System

The *Corporal* represents this country's first ballistic guided missile. System-wise, there is the long pencil-like rocket and several mobile vans and trucks of guidance and firing control equipment. The missile itself is about 45 feet long with steering fins located on the very ends of the large stabilizing fins. It weighs about 5 tons fully fueled and ready for launching.

The missile body contains the same elements as the *Nike* arranged in a slightly different order. There is a warhead, guidance compartment, air tank, propellant tanks, and the liquid rocket motor. The missile is fired vertically from a small mobile launcher.

The *Corporal* is launched into a radar beam in the direction of a distant target. The radar furnishes missile position information to an electronic computer which, combined with data from a special radio set, determines the correct trajectory for the missile to follow. After termination of powered flight by the rocket motor, the *Corporal* follows an essentially ballistic path to the target where the atomic warhead is detonated for the maximum effect.

The trajectory problem for the *Corporal* is somewhat simpler than that for the *Nike*. Here, the missile system is concerned with a fixed ground target so that the resulting computing equipment is not as complex. Before the missile is fired, basic firing data is computed for the guidance equipment and entered as "dial settings" in the various vans. Then, after the rocket is launched, minor corrections are made to the trajectory to insure an accurate impact.

Preparations for Firing

The *Honest John* missile travels to a launching site which has been prepared for the firing. The launcher-truck is emplaced and the launcher is turned to the firing direction or azimuth and to the proper elevation for the required range. The elevation and

azimuth have been determined by a fire direction center which considers such factors as the weight of the rocket, the temperature and density of the air, rotation of the earth, and the burnout velocity of the missile. The effect of these factors on the range and direction to the target is computed and the settings are sent to the launcher.

Final checks are made, the effects of the surface wind computed, and the firing crew retires to a protected firing pit to wait for the designated time to fire. At the pit a final continuity check is made and the firing switch closed at the correct moment.

Nike & Corporal on the Alert

Bridging the Atlantic back to the outskirts of Chicago, we find a *Nike* battery rehearsing their deadly trade as they prepare to go through a practice alert. Every operation is performed as it would be in a "hot" engagement except for the launching of the missile.

The battery control officer sits in his control van located in the same area as the three radars and computer. He is responsible for the execution of the entire operation and he alone makes the final decision to fire. Information is constantly fed into the control console to enable him to make this crucial decision.

He has been notified by early warning radar networks of an unidentified aircraft approaching his defended area—the great population complex of Chicago.

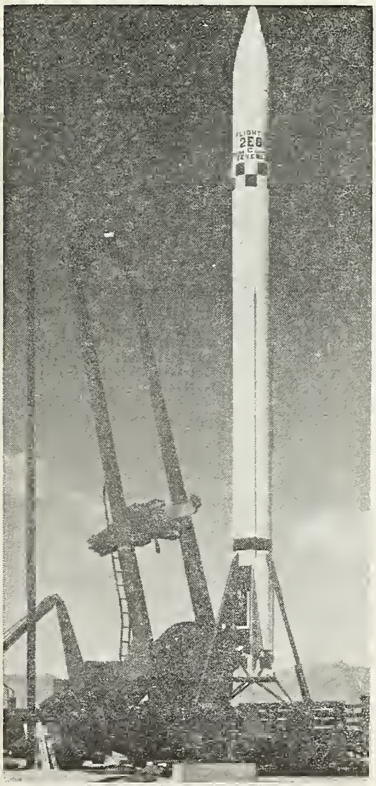
Given the information that an attack is imminent, he immediately orders "Battle Stations!" and the crews move swiftly into action. Previously prepared missiles and boosters are raised to the ground surface on elevators from the underground launcher installation. These two-stage rockets have already had their propulsion and guidance components checked, propellant tanks filled with acid and JP-4, and the warhead installed. *Nike's* are loaded on the four launchers associated with each underground installation and final tests and checks completed.

The "hostile" aircraft comes into the range of the acquisition radar and this information is presented on the scopes in the battery control van. Still the target is far away and out of sight of everything but the searching beam of the radar. The word is flashed to the control officer from the operations center to "Engage!" and the command is relayed to the launchers. Everyone scrambles into the underground installation and the missiles are erected to firing position.

Now comes that decision of the battery control officer . . . when to fire. Hesitation or a mistake might let the bomber slip in close enough to drop his atomic weapon. The battery is placed under its final "red" alert status and the missile tracking radar slews and locks on the first missile to be fired.

As the target approaches the maximum range of the *Nike*, the firing button is pushed. The "engagement" is ended, a few more commands are given and the nation's first operational anti-aircraft guided missiles disappear into their underground lairs waiting for the next alert, hot or cold.

As we return to the German Black Forest, the *Corporal* battalion is under way in the occupation of its forest position. The missile is erected on its launcher by a large transport vehicle called the erector. Previous to this the propulsion and guidance components have been thoroughly checked for proper functioning, the propulsion tanks have been filled with acid and aniline, and the warhead attached.



Corporal on launcher.

Guidance equipment vans have been emplaced somewhat to the rear and they are being warmed up and checked for the proper electronic indications that will guide the *Corporal* to its target.

In this guidance area, the battery commander has established his communications for control of the firing. Here, also, the fire direction center has computed and determined the firing data for the target located many miles behind the "enemy" lines. Since the missile has been erected and final preparations completed, the commander orders all stations to stand by for the countdown to firing time.

The firing crew takes cover in the firing pit. In order to coordinate the sequence of operations before the missile is fired, the remaining time to fire or countdown is announced over a common telephone line or "hot loop" connected to each critical station. All operators follow sets of procedures that insure complete coordination between the ground equipment and the missile as its internal components begin to warm up and prepare for the flight to the target. The commander follows the action of the operational sequence on the hot loop.

As the last few seconds are called, tension has mounted even though this is a "dry run". Finally: *FIRE*! A, B, C, D, Missile Away! And now, as plus times are chanted, operators closely monitor their meters and dials because the guidance equipment still registers this as an actual flight. After the timed sequence of the trajectory has terminated, a report is made to headquarters as to the effectiveness of this atomic blast.

The 1956 silhouettes of the three Army missile systems set the pattern for the future. They are established weapons standing guard and furnishing us with the initial experience and knowledge that will be applicable to the Army's future missile systems. END.

PRELUDE TO THE ICBM

An important and unique element in the Air Force's gigantic program to develop the intercontinental ballistic missile (ICBM) is the X-17 research vehicle, provided by the Missile Systems Division of Lockheed Aircraft Corp., Van Nuys, Calif.

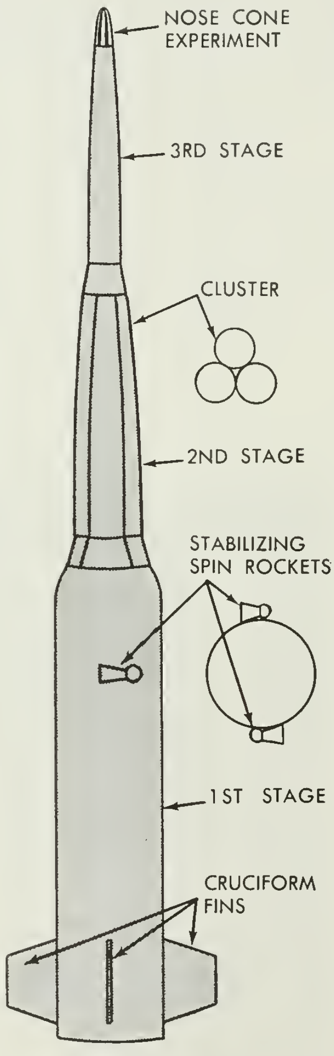
The X-17 is a lash-up of existing missile and rocket components, all of them modified to the extent necessary for the vehicle to accomplish its peculiar task. First stage is believed to be either a *Redstone* or *Corporal* liquid-propellant rocket. The former is made by Chrysler Corp., while the latter is supplied by Firestone Tire & Rubber Co. Second stage is a cluster of three solid-propellant rockets, reportedly *Sergeants*, which are supplied the Army by Thiokol Chemical Co. Third stage is a single solid-propellant rocket, also said to be a *Sergeant*.

The X-17 is now in use at Patrick AFB, Fla., to gather data on nose cone re-entry problems. First two stages carry the third into the ionosphere and detach. The third stage rises to the peak of its trajectory and, as it begins the long fall back to earth, it ignites and roars downward at hypersonic speeds. Information gathered from thermocouples and other instruments mounted in the nose section is telemetered back to Patrick during this portion of the flight.

Tremendous Speed

The existence of the X-17 was first revealed in August at the Air Force Association convention in New Orleans, although even then the designation was not revealed. Here is what Lockheed was permitted to say at the time:

"The test missile hurtles out through the earth's atmosphere at speeds far in excess of the velocity of sound. Within seconds after it is fired, the missile blasts through the sonic barrier and pierces the ionosphere—a layer of very thin air starting some 50 miles above the earth and extending to about 250 miles. Lockheed's missile scientists designed the vehicle to plunge at tremendous speeds from the ionosphere into the earths' heavy blanket of air.



Artist's drawing of Lockheed's three-stage X-17 nose cone research vehicle. Assembly supposedly is capable of reaching velocities and aerodynamic heat levels in the neighborhood of those confronting the ICBM warhead on its return trip to earth. Note the small auxiliary rockets mounted high on the first stage to spin-stabilize the finless second and third stages.

"Although the results of the project cannot be disclosed, it was revealed that the missile division's scientists and engineers are investigating atmospheric heating effects, suitability of various metals, and other important factors contributing to the design of missile nose cones."

Test results with the X-17 to date have apparently been inconclusive. The vehicle reportedly has not achieved anything like the enormous Mach numbers (18-plus) which are in store for ICBM warheads. Highest speed for the rocket assembly so far is said to be Mach 4 or 5—on the order of 2500 mph. While this may seem disappointing, it is obvious that a vehicle with as much beef as the X-17 should eventually be capable of much greater speeds.

NACA Goes to Mach 10

In this connection, it is interesting to note that the National Advisory Committee for Aeronautics has achieved some enormous velocities with relatively modest four-stage rockets at its Wallops Island, Virginia, research station. (See article, page 82.) One assembly has achieved a Mach Number of 10.4, and still greater speeds have probably been attained but not yet released. Like Lockheed's X-17 program for the USAF's Western Development Division, the NACA program is designed to secure detailed information on the problems of aerodynamic heating.

Lockheed is one of three prime contractors selected by WDD to handle the nose cone phase of the ICBM program. The others are General Electric Co. and Avco Manufacturing Co., both of which are working on competing nose cone design proposals for the ICBM. Lockheed is responsible for securing test data and passing it on to General Electric and Avco.

SOLAR POWER for spacecraft

This outstanding technical article investigates some aspects of space operations by hydrogen in high-specific impulse solar power drives. The interesting concept of pressure-stabilized spherical reflectors for water-oxyhydrogen conversion in space, and the solar power drive itself, not only seem feasible, but such a system can be constructed without too much effort.

By Krafft A. Ehricke

CONSIDERING density, specific impulse, design parameters and flight performance, light, high-specific impulse propellants for space vehicles have advantages.

Light-weight propellants are combinations of hydrogen-oxygen, hydrogen-fluorine, methane-oxygen or methane-ozone. By comparison, medium propellants are ammonia, gasoline or hydrazine with oxygen, ozone or fluorine. Heavy propellants are hydrazine with acid or with chlorine trifluoride.

In the atmosphere, and at relatively lower levels of flight performance, high density is preferable even at the expense of high specific impulse. In space where few, if any, shape requirements exist, but where high flight performance is usually required, light propellants of high specific impulse are more desirable. These propellants are liquid gases which require protection from intense solar radiation by double-walled or light multilayer tank construction. This is not difficult and also does not seriously affect the mass ratio, if the containers are sufficiently large.

Chemical space vehicle proposals have usually been based on medium or heavy propellants, mainly because supply ships were assumed to operate with such combinations. It is entirely feasible to base upper stages of a supply vehicle on light propellants.

For nuclear pile heating, hydrogen is most attractive since it is suitable for porous cooling, has a high heat content and a very high specific impulse. It does not become radioactive when passing through the pile and does not contaminate the launching site.

Finally, long-duration astronautical operations suggest considering the manufacture of hydrogen in space, using materials which may be more readily transported from the earth. The manufacturing process could be based on electrolysis of water or on the thermal decomposition of methane.

By transporting water the energy is supplied in 2.5 times as concentrated form as if the components were supplied separately.

Hydrogen-manufacturing satellites could rely on concentration of solar power in power collectors. The manufacturing process could be completely automatic, requiring only occasional human supervision and maintenance.

Solar Power Collector

Because of the low concentration of solar energy in terrestrial space, large radiation collectors are required to yield an adequate energy concentration. The resulting large dimensions of a solar-powered vehicle require very long pipelines from tank to heater and back to the exhaust nozzle. Elaborate insulation of these lines is not practical for weight reasons. Regenerative cooling is not feasible because of insufficient quantity of working fluid in view of the length of pipelines and because of excessive pressure losses in the cooling jacket.

For this reason the working fluid in a solar-powered system must operate at temperatures which are sufficiently low to permit uncooled hot-gas ducts of high-temperature material, such as Inconel X. This consideration limits working temperatures on the hot side to some 1,000°K (1,340°F).

As a result, no spectacular increase over chemical drives can be expected by any type of working fluid. By selecting hydrogen, however, a maximum of energy can be stored at the above mentioned temperature limit, because of the high specific heat of this medium. Therefore, a quite attractive specific impulse can be obtained at high expansion ratio. (Assuming an expansion ratio of 15/0.1 atmospheres and an initial temperature of T_c=1,000°K, the theoretical specific impulse is 478 sec., or about 450 sec. as practical value, considering losses in the nozzle only).

Dominant factor in the layout of the reflector system will be a compromise between reflector size and thrust power, leading to low thrust and large reflectors.

Therefore, lowest possible reflector weight is the dominant consideration in solar-powered space ships. Parabolic reflectors, because of their shape, cannot be built sufficiently light under the stresses involved. Furthermore, they tend to concentrate solar energy in too small a focal area for the heating of the working fluid.

A solution to the collector problem is the use of a pressure-stabilized spherical collector, one half of which is sprayed with silver or aluminum. The sphere can be stabilized at a very low pressure. The stress is minimized and permits a collector of record low weight. At the same time, the spherical reflector produces a larger focal area than does the parabola. More desirable heat transfer for propulsion conditions are thus achieved.

The collector sphere must consist of transparent, low-weight material. Polyester (polyethylene terephtalate), a highly transparent plastic, could be used. At 0.001-inch thickness the material has adequate tensile strength. A pressurization of 0.01 psi is sufficient under space conditions to lend adequate rigidity to the sphere proper. Perforation of such a sphere by micrometeors is not considered critical. Due to the size of the sphere, practically no reduction in reflectivity is caused by individual perforations and the resultant holes would yield only negligible pressure losses, at the volume involved.

Assuming 90 percent light transmission through the transparent portion of the collector, 90 percent reflectivity (a conservative value if silver is considered) and 90 percent efficiency in energy transmission from the heater to the expansion nozzle, one obtains an efficiency of 0.729.

Solar-Powered Space Ship

A prototype solar-powered space vehicle might consist of two collector spheres (128 ft. in diameter), with the hydrogen sphere between them. The three spheres are connected by the axis of rotation.

The Author . . .

is Chief of Preliminary Design and Systems Analysis Group Convair Astronautics Division, builders of the Atlas ICBM. He is a member of M/R's Editorial Advisory Board. This article is a condensed version of a paper presented at the IAF Congress in Rome in September.

Normal to this axis are the optical axes of the reflectors. Connected rigidly to the hydrogen sphere are the exhaust nozzle and the crew gondola, forming the thrust axis normal to the axis of rotation.

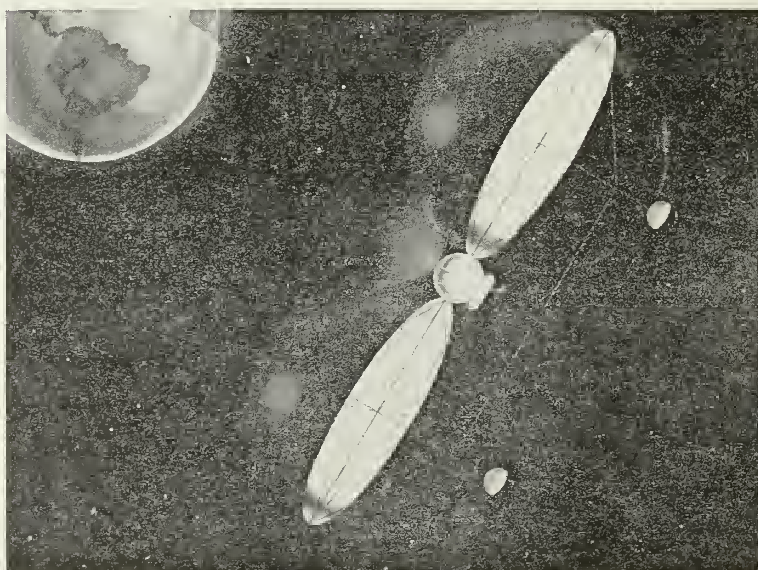
The two collectors are braced by guy wires so that they rotate together, but independently of the hydrogen sphere. The whole vehicle, being fully symmetrical, can rotate about the thrust axis (roll). Thus the thrust axis and the optical axis may be directed independently.

Hydrogen is pumped from the container to the heat exchanger and ducted back to the exhaust nozzle. Even at low acceleration aluminum cross-tubes which form the axis of rotation and which are very light would be deflected about 51 ft. at the outer ends if the structure were not properly rigged by spring-tensioned Inconel X wires.

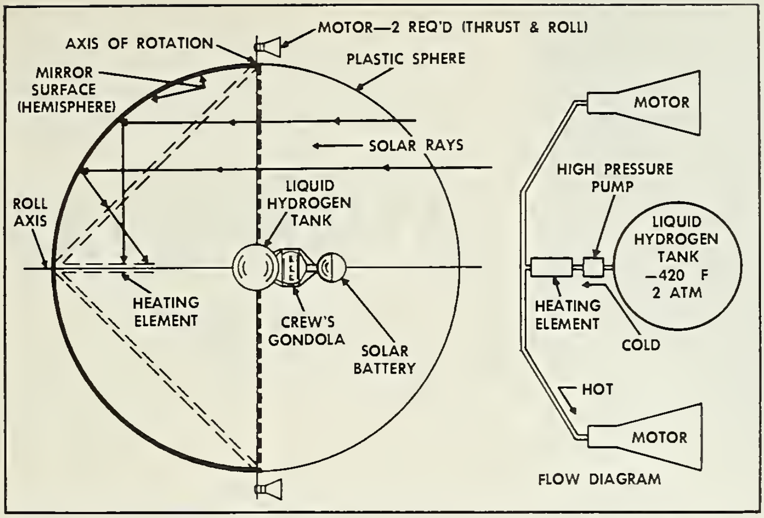
The rigging is three-dimensional and may be seen more clearly in the artist's illustration of such a vehicle. High heat-resisting material has been selected for the wires, because they may get into the path of the exhaust jet. Spring tension is necessary because of temperature variations.

The prototype carries 11,000 lbs. of liquid hydrogen. In a chemical rocket an additional 45,000 to 50,000 lbs. of oxygen would be required to produce a specific impulse of about 380 sec. under equal conditions of expansion ratio and losses in the nozzle. Instead of oxygen weight, the solar-powered vehicle uses only 1,000 lbs. in the form of radiation collectors. In this fact lies the potential logistic advantage of the solar-powered space ship over the chemical rocket for cislunar operation.

However, the solar-powered system also has a number of severe problems which make the development and operation of such vehicle anything but straightforward. Its enormous size certainly exposes it to more damage by meteors and cosmic dust. With the present lack of accurate knowledge regarding the density and density variations of small meteors and cosmic dust, it is impossible to predict how long a collector sphere of the above-described type can be maintained in adequate condition. This time, disregarding maintenance, may be disappointingly short.



Artist's conception of solar-powered spaceship.



Schematic drawing of hydrogen-powered solar-driven space vehicle and flow diagram showing motors and tank position.

On the other hand it is possible to patch up holes in the spherical polyester shell easily and the thin material coating of the reflector part can be renewed periodically.

Another problem area is the starting and operation of the propulsion system. The structure will tolerate only very low accelerations. Thus the static head in the hydrogen tank is practically negligible. It will be necessary to provide displacement bodies or solid-propellant starter rockets to produce some pressure at the tank outlet. Fortunately, the fuel consumption is very low (about 0.35 lb/sec).

Much hydrogen must be pumped into the long pipelines before the system begins to work. In the prototype vehicle the total volume of the cold tubing is about 1.1 ft.^{3}, corresponding to about 4.5 lbs. hydrogen. To this must be added the hot tubing with 15 ft.^{3}, containing about 0.3 lb. hydrogen; the resulting total is more than 13 times the consumption per second.

Friction losses in the long pipelines is another important consideration. Not much practical experience is available in this respect with hydrogen. In order to keep these losses down, low pressure flow (3 to 4 atm) is assumed in the lines leading from the tank to the center of the collector sphere. There the hydrogen enters a high-pressure pump to increase the pressure to supercritical values of 17 to 20 atm, to intensify the heat transfer.

Thus the pressure at the high pressure pump outlet has been assumed to be somewhere between 17 and 20 atm, to maintain 15 at the expansion nozzle inlet. Bubble formation in the pipelines due to the low acceleration, especially at the low pressure of the cold lines, may cause an upward revision of the pressure. Fortunately, again, the reflector must be turned away from the sun to protect the heater. In space this will keep the feeding lines exceedingly cold, thereby greatly reducing or even eliminating the danger of vapor lock.

Additional problems result from the material selection for the collector spheres. The polyester plastic has considerable tensile strength at room temperature and at least 10,000 psi at 150°C (300°F). But it will be necessary to test the material against temperature variations and, above all, against the more intense and active solar radiation before a final decision as to its application can be made.

Operationally, the crucial problem will be the dynamics of the orientation and alignment of thrust axis and optical axis, respectively. In view of the size and fragility of the structure, extremely careful balancing of the collector weights and their content is necessary. This again underlines the need for low thrust values. Even so, large moments could be produced, which adversely affect the autopilot operation; hence the accuracy of flight.

The flight mechanics of a low-thrust vehicle, such as a solar-powered space ship, differs from that of a high-thrust vehicle, such as the conventional chemical rocket. A flight under low-thrust conditions involves longer burning times and greater changes in potential energy than in the chemical rocket. Chemical vehicles in an orbit generally must have an initial acceleration of at least 0.25 *g*. Burning times are measured in minutes.

Initial acceleration of the low-thrust vehicle is four per cent or less than that of the chemical rocket. Burning times are measured in hours or days. Thus, propellant is lifted to considerably greater altitudes before it is consumed. This lifting of propellant mass is comparable to a non-isentropic thermodynamic process and, like such processes, carries a penalty in the form of an energy (gravitational) loss.

In powered ascent from the surface, minimization of the loss plays an important role and leads to trajectories which deflect from vertical direction as rapidly as aerodynamic considerations permit.

The question of what maximum collector size can be manufactured is separate from the operational value of the solar power drive. The conditions under which this drive is attractive should be established first. The author feels, however, that if the need arises, industrial research will make the fabrication of 200- to 300-ft. diameter spheres practical. These spheres would be made on earth, inflated under protection from wind loads and silver-coated.

The tensile strength of the material permits pressure stabilization on the surface of the earth. Thereafter the collector is deflated and folded for the transport into space where it is carefully re-inflated and the equipment installed.

Theoretically, the construction of solar-powered space vehicles seems within reach—indeed, the design parameters are rather simple—but it remains to be seen and done. The basic requirement for realization of the job must be experimentation with models, plus a greater knowledge of space. END.

En route to another galaxy, visualized by artists Miyazeki, Sato.

ASTRONAUTICS in JAPAN

By Frederick C. Durant III

GREAT interest in astronautics has developed in Japan in the past few years. One popular exhibition on space flight at the Inuyama Amusement Park last year pulled in an average attendance of 10,000 each weekday and 30,000 per day on weekends and holidays. The exhibition ran for only 2½ months—total attendance topped one million. For a nation of about eighty million this is rather dramatic evidence of popular interest.

Focal point of astronautical interest is the Japanese Astronautical Society (JAS). The Society's chairman is a respected and experienced radio science-commentator, columnist, author and lecturer—Mitsuo Harada. In a manner belying his age (66 years), Harada has been fascinated with the possibilities of space flight since Robert Goddard's famous Smithsonian paper of the early twenties.

Orbital vehicles over Japan.

JAS is governed by a board of nine directors and a commission of trustees numbering perhaps fifty. The directors are closely concerned with society activities such as the various exhibitions and lectures. Among them are impressive titles and affiliations, such as:

Dr. Hideo Itokawa—Professor Tokyo University; Chairman, Sounding Rocket Panel, Japanese National Committee (IGY)

Dr. I. Yamamoto—President, Yamamoto Observatory

Dr. T. Hayashi—Professor, Keio University (Physiology)

Dr. T. Asada—Professor, Osaka University (Nuclear Physics)

Dr. H. Kimura—Professor, Nihon University (Aerodynamics)

Dr. Y. Niwa—Professor, Tokyo University (Communications)

Dr. N. Nishiwaki—Professor, Tokyo University (Engineering Dept.)

Dr. T. Hatanaka—Professor, Osaka University (Astronomy)

Another director, Mr. M. Tokugawa, is one of the oldest and best known radio actors in Japan. He advises on public relations.

Since the organizational meeting of JAS in September 1953 membership has passed the 1,000 mark. About one-half of this number represents students. Much effort has been directed towards Japanese youth, describing and interpreting basic rocketry and postwar missile developments in other countries. As might be expected the directors hope that one day Japan may be able to make positive contributions to the science and technology upon which space flight will be based. In the meantime, youth is developing an interest and a desire to understand and study in related scientific disciplines. JAS attempts to further this interest on the basis of scientific knowledge.

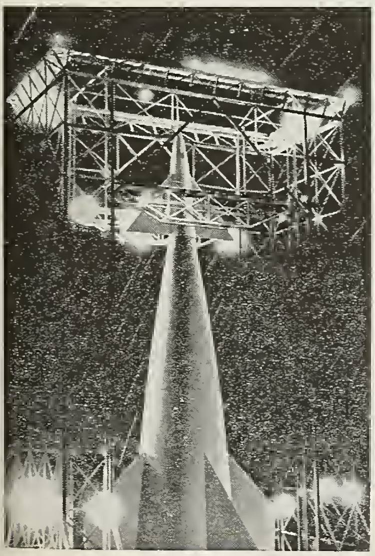
In all, six exhibitions have been arranged under the technical direction of Harada or other directors during the past three years. Contributing to the outstanding success of the Inuyama exhibit, mentioned above, was a rocket and perisphere, each some 85 feet high, through which the audience was conducted. The Chubu Nihon Press and Nagoya Railroad Company were sponsors. An exhibition was held in January 1954 near Tokyo under the sponsorship of the Yomiuri Press and the Tokyo Express

Line. Another was at Osaka in October-November 1954 under the sponsorship of the Kei-Han-Shin Kyuko Railway Company, Ltd. The major exhibit this year was at the Korakuen Amusement Park.

The Japanese Astronautical Society is actively spreading an interest in the fundamentals of space flight to youth and to the public. The popular response has been great. As pointed out in the earlier story on Japanese Rocket Research (M & R October 1956) Japan has commenced and is making rapid strides in small scale rocketry. JAS is not itself engaged in rocket experimentation.

In 1954 a rocket research society was organized by Professor Nishiwaki of Tokyo University. Known as the Rocket Kenkyu-Kai, its membership was small. Late this summer Dr. Hideo Itokawa organized the Japanese Rocket Society along the lines of the professional American Rocket Society. Industrialists, scientists and representatives of both houses of the government were present.

It is understood that this society encompasses the Kenkyu-Kai. This professional activity is essentially non-competitive with the aims of the Japanese Astronautical Society and both organizations may be expected to play an increasingly important role in future Japanese rocket development.



Ferry vehicle in gantry tower.

BRITISH MOVE AHEAD

At a recent meeting of the British Interplanetary Society in London, Prof. H. S. W. Massey of University College, London, discussed the part the British upper-atmosphere rocket *Skylark* will play in the forthcoming IGY program.

The solid-propellant rocket is designed to reach about 100 miles altitude. The British program is to be a selective rather than an all-embracing one, and each item chosen for investigation will be treated very thoroughly. Upper atmosphere temperatures and winds, for example, are to be studied by means of firing grenades from the rocket at regular intervals, measuring the time which both flash and sound require to reach the ground.

Difference in mean sound velocities from various heights will give a measure of the variation of temperature, and the angle at which the sound reaches the ground microphones will allow the speed of the wind at various altitudes to be calculated. This is not a new technique, having been previously used by U. S. Naval Research Laboratory, but a refined version of it will be applied.

A more spectacular experiment is the releasing of metallic sodium at about 40 miles altitude at twilight. This will form a luminous cloud, the examination of which by spectroscopic means will give local temperatures. The experiment was first suggested by Prof. Bates of Belfast University, and has already been successfully carried out at White Sands. However, a better method of dispersing the sodium by means of thermit has been developed at Belfast, and this technique will be used in the British experiments.

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Britain's Largest

Royal Aircraft Establishment's Westcott, England, propulsion center has designed and built a 50,000 lb. rocket. Combustion chamber and nozzle are of the skin-cooled type made from thin-gage 18/8 stainless steel with longitudinal ducting for kerosene fuel coolant.

The spherical combustion chamber and divergent nozzle form an integral unit welded together from 32 narrow longitudinal segment consists of two thin blades—like a cavalry saber in shape—which are superimposed and edge-welded together, with a further seam weld along the centerline for most of their length. To the front of the blades (the saber "tip") is a thin stainless-steel tube, which is used to pump fluid into the assembled blade and swell it into a mold, so giving the blade a "quilted look" and forming it into two longitudinal ducts. The "tip" of each blade for about nine inches is perforated with microscopic holes on one side, the inside after assembly.

There are two types of blade; one is hollow throughout its length, the other has a barrier between the perforated tip and the longitudinal ducts. When assembled, the blades are welded alternately. The roots, which form the lip of the divergent nozzle, are joined by a circumferential passage and the forward part at the maximum circumference of the combustion chamber by an external duct welded to it.

Kerosene is delivered to the duct, from which it passes up the barred blades, through the lip duct and down the adjacent blade to squirt into the chamber. LOX is injected from the base of the chamber through the holes in the barred blades. The layout segregates the kerosene and LOX until it unites in the chamber. Combustion pressure is 500 lbs/sq in. and the kerosene is therefore pumped into the hollow skin at 800 lbs/sq in. The Wescott unit is stated by the Ministry of Supply to be the largest bi-propellant rocket to be designed and made in Britain.

International News

By Anthony Vandyk

After working under wraps for several years France's Ouest-Aviation (formerly SNCASO) has disclosed details of its activities in the guided missile field. Company has confirmed that its *Trident* research aircraft is actually the prototype for a surface-to-air missile. The first "pilotless *Trident*" will start its test program shortly. The French nationalized aircraft company also has developed a missile "to complete and perfect the efficiency" of the *Vautour* twin-jet bomber's armament. Ouest-Aviation also has under development various types of strategic missiles with "a completely new" navigation system. Most of Ouest-Aviation's missile work has been financed by the company on a "private venture" basis.

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What's wrong at Britain's missile range at Woomera in the Australian desert? Chapman Pincher, the highly respected science reporter for the LONDON DAILY EXPRESS, estimates that the range is costing about $30 million a year to run but only $3 million worth of useful work is coming out of it. One reason for the slow progress is that the difficulties of using a range 12,000 miles from home base were badly underestimated. Furthermore Woomera was set up with the understanding that British missile firms would transfer much of their work to Australia which would become the arsenal of the British Commonwealth. The companies have refused to uproot themselves and there is no engineering industry in Australia to support a project of this size.

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Japan expects to build its first tactical guided missile about the end of this decade. Meanwhile the Defense Agency is stepping up its program for research work on missiles. A missile experimental unit is to be established within the agency's Technical Research Institute. For fiscal 1957 this unit will have 600 million yen at its disposal, according to the present budget program. Meanwhile, Japan is well advanced in experimental rocket construction. The first firing test of the TMB (Test Missile B) rocket is scheduled for this month. The TMB is manufactured by Shin Mitsubishi. It uses a rocket motor built by Fuji Precision Machinery and a guidance system supplied by Mitsubishi Electric Co.

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First official mention that British defense policy has abandoned liquid oxygen as an oxidant for manned vehicles has come from S. Allen, Chief Engineer of Armstrong-Siddeley Motors' Rocket Division. He told the Royal Aeronautical Society that "liquid oxygen would probably be an unsuitable oxidant for defensive weapons because such weapons could not be kept ready for instant use." For offensive weapons, liquid oxygen is quite suitable, specific impulse being of major importance in reaching extreme altitudes—even at the expense of some engine weight—and, therefore, great range, he added. Allen noted that his company's Screamer 3,000-9, 500-lb. thrust rocket motor differs from Reaction Motors, Walter and SEPR units in being single chambered and truly controllable (by varying the propellant supply).

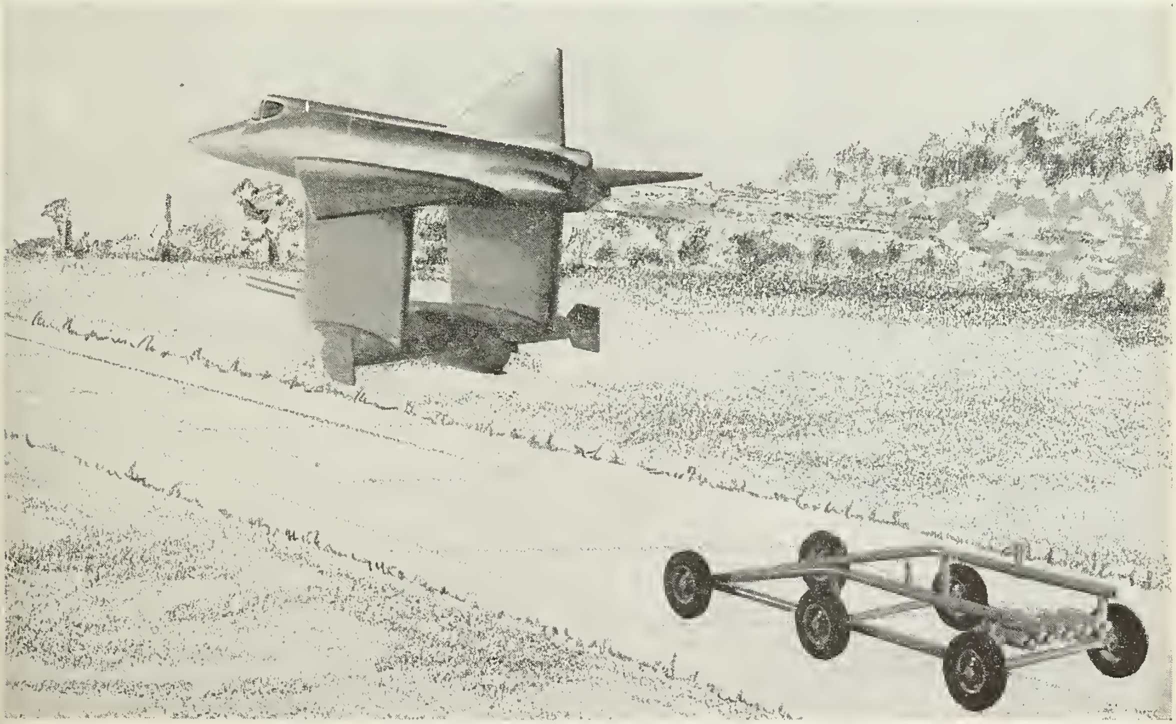
SATELLITE LAUNCHING from an F-102

By Aurelio C. Robotti

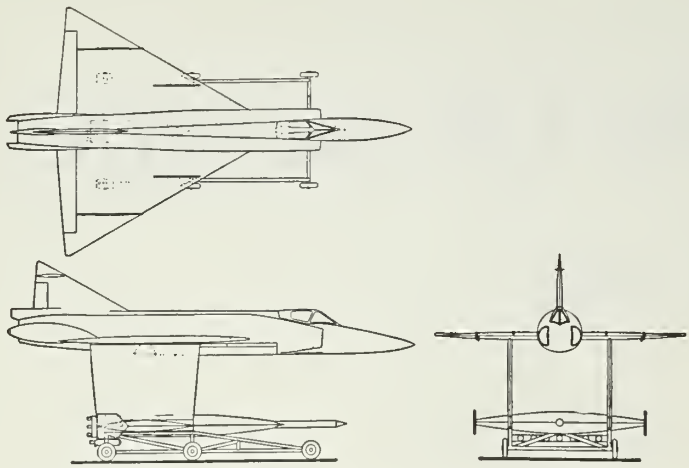
THE concept of bringing a small satellite into orbit by the airplane-launching method is as inexpensive as it is feasible. Airplane-launched satellite proposals to date have been hypothetical and rather difficult to realize because the hardware, as well as the scope of the proposals, have been too gigantic and complex.

However, the feasibility of carrying a two-stage, modified BUMPER type vehicle (A-4 plus WAC Corporal) to 42,000 feet launching altitude by a current airplane, such as a Convair F-102A fighter, has merit. And, furthermore, such an experiment is indicative of what can be achieved when considering new high-energy propellant rockets. When launched at an altitude of 42,000 feet, even the old-fashioned BUMPER will easily reach orbital velocity.

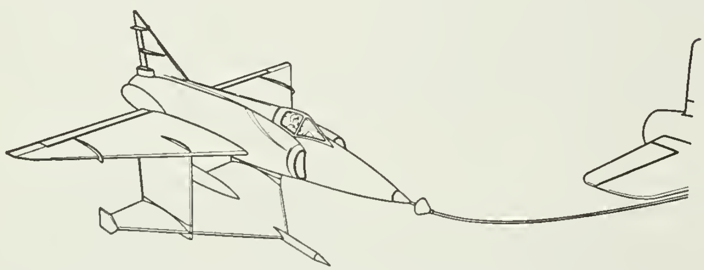
The *Bumper* was launched from White Sands in 1949. At first-stage burnout the altitude was 20 miles. The WAC *Corporal* came into action and reached a maximum velocity of 6,800 feet per second. The



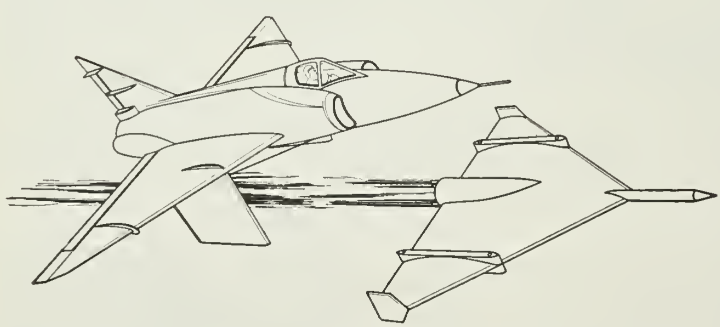
Artist's conception of how F-102A takes off carrying delta-wing satellite vehicle.



General three-view layout of F-102A with delta-wing Bumper type rocket vehicle mounted underneath. Takeoff dolly is fitted with JATO units for extra boost.



F-102A takes off with very little fuel. Rocket vehicle and plane are refueled at altitude. LOX might be dropped as oxidizer because of refueling hazards.



At 42,000 feet pilot releases satellite vehicle. He ejects struts and returns to base. WAC Corporal or similar rocket will be brought into orbit carrying payload.

maximum altitude was 242 miles.

Assuming that a *Bumper* type vehicle is carried to 42,000 feet and launched with an initial velocity (the velocity of the F-102A at moment of launching) of 450 feet per second, a maximum speed of 8,350 feet per second, instead of 6,800, will be obtained for the second stage WAC *Corporal*, and a maximum height of 367 miles instead of 242 miles will be achieved, i.e. an increase of about 50 per cent.

If the *Bumper* is lifted to 42,000 feet with a residual velocity —at that height—of 450 feet per second, by means of a booster, and if the climb is carried out in the most economical way, the booster itself would have to develop a total impulse of 2,600,000 lb. sec. Specific impulse of 185 sec., and a gross weight of about 20,000 pounds are encountered.

The *Bumper* would be transformed into a three-step rocket whose first stage would weigh ten tons. This first stage is represented by the delta-wing F-102A.

Considering the total weight of the *Bumper* and the performance of the F-102A, it is easily understood that the plane could not take off with an overload of more than 12 tons. Furthermore, it would be practically impossible to obtain a reasonable hook-up device between the two structures.

Delta-Wing Rocket

To solve these problems, it is necessary to give the rocket a lifting feature—possibly a delta-wing with a base and a height of about 27 feet. The *Bumper* would then have a total weight of 27,000 pounds and a wing load of 60 pounds per square foot. The WAC *Corporal* rocket will be partially lodged in the nose of the delta-rocket.

The approximate weight distribution of the A-4 in the original

The Author . . .

is a recognized aeronautical engineer and a key Italian rocket personality. He is Technical Consultant to Italy's well-known Fiat concern. This article is based on a paper presented by the author at the 7th International Astronautical Congress.

Bumper configuration was:

Structures	827.5	pounds
Engine	191	"
Pumps	150	"
Propellants	82	"
Servo mechanism .	113.5	"
Ethyl alcohol and water	1630	"
Liquid oxygen	2432	"
Total	5426	pounds

A delta-winged A-4 has the same distribution of weights, spaced cylindrically in the middle of the structure.

The delta-winged A-4 can be attached to the "mother" plane by means of two vertical frames, linking the wings of the plane to those of the rocket. The rocket rests on a takeoff dolly which will remain on the ground when the plane takes off. The tanks of the A-4 are empty, which means that the whole structure has the modest average wing load of 28 pounds per square foot.

At a suitable altitude a tanker will refuel the A-4 by pumping into its tanks 1,200 gallons of fuel and 1,400 gallons of oxidizer.

At 42,000 feet the pilot will ignite the first-stage rocket engine and, as soon as the thrust has reached its proper level, will actuate the launching of the missile and start its teleguiding. The two-step rocket, under the action of its guidance and graphite fins, will bring the vehicle into the trajectory that will take the rocket into an orbit around the earth. Once the separation has been effected, the pilot will jettison the frames joining the rocket to the plane and return to his base.

This proposal is an invitation to the study of the general problem of carrying large rockets to high altitude by means of aircraft.

Most obvious aeronautical problems that would be met in applying this proposition might be:

a) Aerodynamic interference between the planes of the biplane configuration. A biplane with wings of aspect ratio lower than 1 has no precedent in the aeronautical proxis and therefore represents a case to be wind tunnel tested.

It is certain that by sufficiently increasing the distance between the planes, the danger of interference is eliminated. This danger is especially serious at takeoff, when the increased angle amplifies the mutual disturbance of the two planes. However, takeoff is the only critical stage of the flight. The climb can be performed at a low angle.

b) Flight refuelling is currently used and does not present problems, even in a case where two propellants are involved.

c) Condensation on the rocket tank walls creates a problem. In the A-4 alcohol and liquid oxygen were contained in tanks inside the missile. In the delta-rocket proposed here, the use of the body covering plates as tank walls might save weight. However, it is likely that the atmospheric humidity will condense on the outside of the tank walls, producing an ice formation during the climb to 42,000.

Obvious remedies are two: either to employ an oxidizer different from liquid oxygen or to insulate the tank walls. A reverse problem, that of the fuel condensation on the inside face of the tank walls must also be considered.

d) Takeoff gear. No serious difficulties are involved in making a takeoff gear that remains on the ground when the rocket-carrying F-102A takes off. The same gear can be accelerated by a number of JATO rockets.

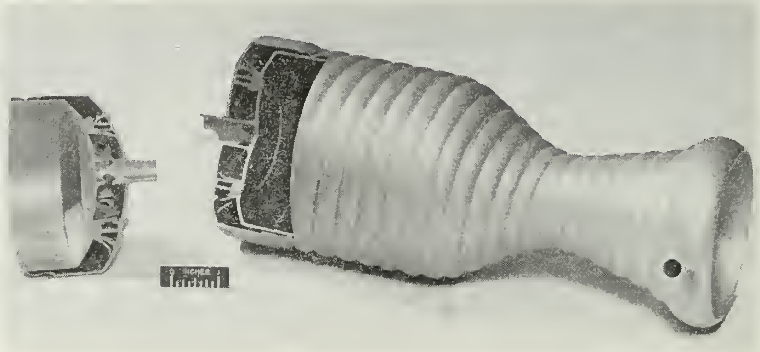
e) Maneuverability. Of course, the tail surfaces of the F-102A have not been designed to control the biplane constellation discussed here, but the biplane does not have to carry out abnormal maneuvers.

f) Supporting frames. The triangular design of the two wing planes offers good possibilities for a strong joint of two interplane struts. All vertical stresses rest directly on the takeoff gear through two strong compression ribs of the lower plane. Naturally, the struts present one of the most important structural design problems, since they have to make possible the launching of the rocket.

It seems obvious that aircraft can be used advantageously as carriers of orbital payloads. It should be emphasized also that the vehicle proposed here may take off from conventional air strips. END.

NEW ROCKET FABRICATION METHOD

Experiments have been conducted with a jacketed rocket combustion chamber that was fabricated by hydraulic forming from sheet metal, according to NACA.* Runs with these combustion chambers have been made at over-all heat-transfer rates of 2.5 BTU per square inch per second with water cooling and also with ammonia as a regenerative coolant.



Thrust chamber manufactured by hydraulic forming.

New fabrication method not only provides chambers with thin walls for combustion and cooling research, but also affords relatively light-weight chamber structure, NACA reports.

Engine involved has a nominal thrust rating of 1,000 pounds at a chamber pressure of 300 pounds per square inch. Thrust chambers of 1,000- and 5,000-pound thrust with operating chamber pressures of 600 pounds per square inch have been made by the same technique.

Coolant jacket comprises an inner and outer sheet-metal skin. Outer skin is shaped to form three or four helically wound coolant passages. In the engine illustrated these coolant passages lead directly into the rocket injection head, thus providing for regenerative cooling of the chamber.

For engines operated at a chamber pressure of 600 pounds per square inch with regenerative cooling (jacket pressures of the order of 800 lb/sq. in.), it was necessary to reinforce the outer shell to prevent ballooning. Such reinforcement was accomplished by wrapping the chamber with several layers of fiberglass cloth, bonded with a polyester resin glue. External valleys between adjacent cooling passages were first filled with a low-strength filler material.

For research purposes, where engine weight is not a primary consideration, the chamber assembly is welded to a flange to permit attaching an injector and to facilitate mounting on the thrust stand.

Thrust chambers fabricated by the hydraulic-forming method have been used in a number of experimental programs. Propellants used include liquid oxygen and ammonia, liquid oxygen with hydrocarbons, and high-impulse propellant combinations. For liquid oxygen with either ammonia or hydrocarbons as fuel, regenerative cooling as well as water cooling has been used. Run duration ranged to 60 seconds.

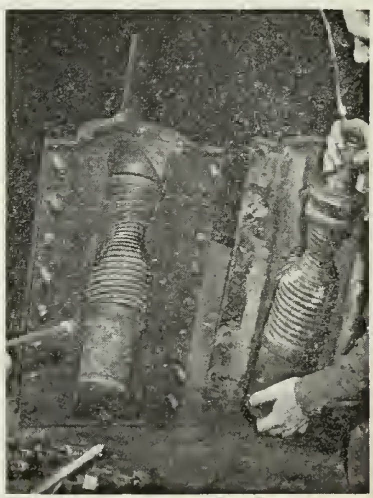
The characteristic length was usually between 30 and 40 inches. In all cases, nozzles designed for expansion to atmospheric pressures were used.

Time and Cost Savings

These engines were proved to be rugged and durable in the tests, according to NACA. Over-all heat-transfer rates above 5 BTU per square inch per second were measured with high-impulse propellants in a 1000-pound-thrust engine without failures. Occasional burnouts were experienced. Some of these burnouts occurred at the throat of the engine. Such burnouts could generally be attributed to the injector design; that is, similar burnouts were experienced with substitute chambers equipped with the troublesome injector. Heat-transfer rates with such injectors have usually been very high.

For the fabrication of more than one rocket combustion chamber, the new technique has resulted in time and cost savings over the contour machining methods that it replaced. The total time for one chamber is about equal to that required for an equivalent machined rocket chamber. But, an additional chamber can be made with a completed die in 10 per cent of the time required for the first chamber.

Thus, it is clear that when several chambers are made, the cost per chamber is greatly reduced. Material costs are also lessened. The procedure produces very little scrap metal. Exclusive of the material in the mandrel and die, 60 per cent of the starting metal ends up in the final chamber assembly.



Removal of 1000 lb. thrust chamber from die.

* Technical Note 3827, Experimental Investigation of a Lightweight Rocket Chamber, by John E. Dalgleish and Adelbert O. Tischler.

BRITISH LIQUID ROCKET VALVES

Four outstanding main types of valves used on Britain's *Screamer* rocket, suction valves, stop and by-pass valves, pressure operated air valves, and control valves, represent proof British engineers have accomplished a great feat.

Details on these valves have been revealed by S. Allen, Chief Engineer, Armstrong Siddeley's Rocket Division.

In a R.A.S. report he points out suction valves originally were kept to a minimum in size to give a small resistance to flow. This gave the head of the valve the rather long travel of 0.95 in., and for this reason a long stack of bellows had to be used.

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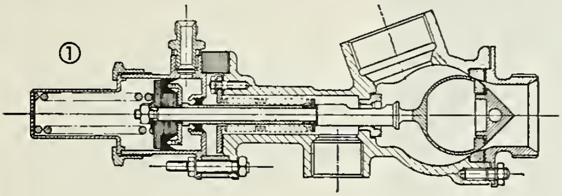

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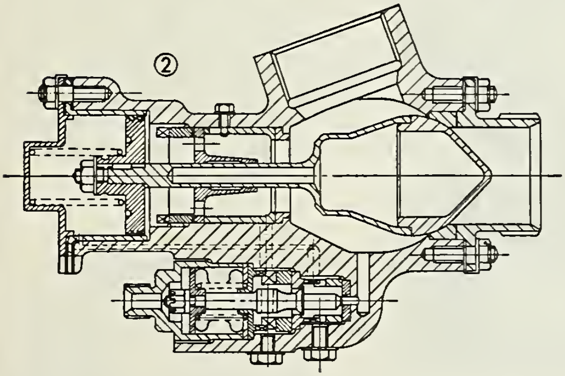

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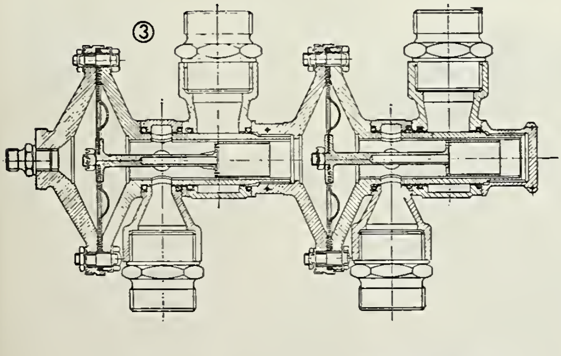

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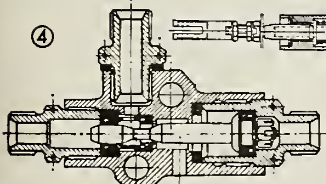

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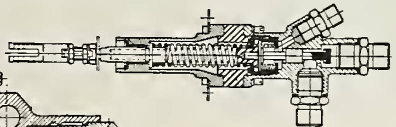


The main *stop valves* incorporated by a *by-pass valve* allowed the pipe lines and valves to be cooled before starting. Allen terms the liquid oxygen stop valve "typical", the original design is shown in Fig. 1. Valve head was operated by gas pressure acting on a bellows. By-pass valve was carried on the stem of the stop valve, passages being provided by flutes. By "masking" the by-pass valve a certain amount of cushioning was achieved during opening of the stop valve. As the stop valve opened, the by-pass valve closed.

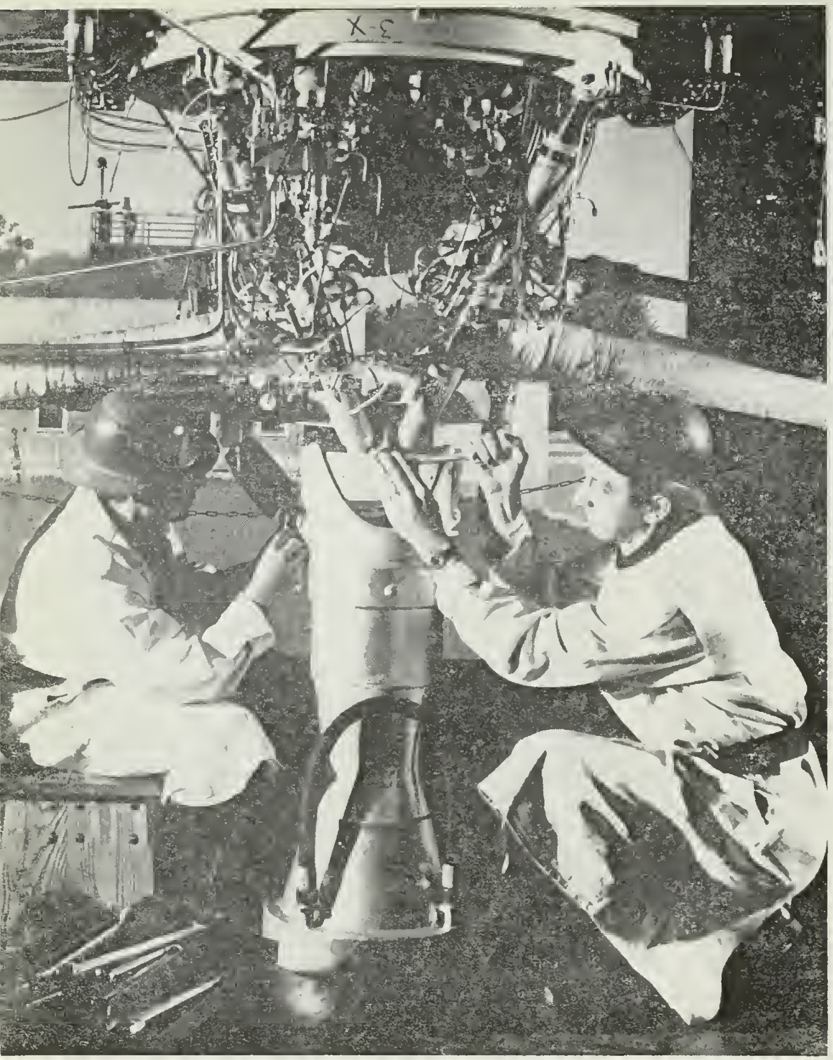
It was necessary to apply a large force to the valve head to move it against a large pressure difference. When the valve opened, the pressure difference disappeared and the force caused the valve to accelerate so rapidly that stress waves were set up in the bellows, causing rupture. For these reasons a different type of valve was developed, as shown in Fig. 2. In this unit a small bellows-sealed servo valve is used to control the pressure behind the main operating piston. When the pump primes, fluid is delivered against a comparatively small back pressure through the by-pass. Both sides of the operating piston are subjected to this pressure; the valve is held on its seat by the force of a "fail safe" spring and by force given by the pressure and area valve head.

Small valves used to control the flow of propellants to the igniter and gas generator were of similar design to that of the pilot portion of the valve illustrated in Fig. 2.

To control the gas pressure necessary to open the various valves, a design of pressure-operated gas valves was developed, as shown in Fig. 4. Signal pressure moves piston against the spring until the cone forming the back of the piston registers on a seat giving a positive seal. This moves the necked portion of the spindle in line with a lip seal, thus providing a passage from the pressurized gas storage to the operating cylinder of the valve to be used.

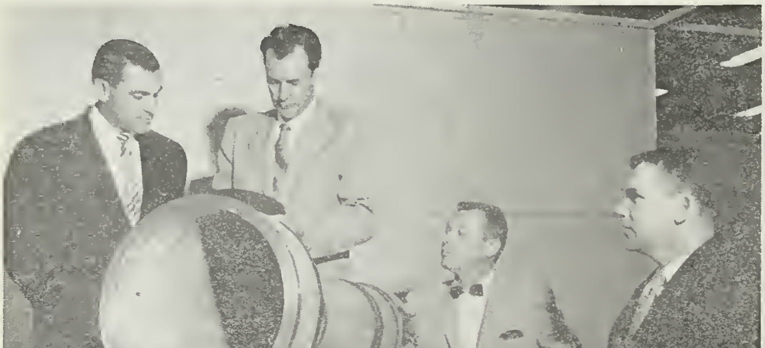
The *pressure balance valve,* which is illustrated in Fig. 3, consists of two diaphragms each carrying a ported piston. Oxygen pressure acts on one side of the first diaphragm and water pressure on the other. Excess or deficiency of water pressure over oxygen pressure causes the ported piston to slide in its barrel adjusting water pressure to the oxygen pressure by altering the area of the ports.

Thrust variation is obtained by variation of the turbine speed by means of controlling the flow of propellants to the gas generator. LOX flow to the gas generator is controlled by the pilot's throttle valve illustrated in Fig. 5. This essentially is a *variable datum reducing valve,* the datum being altered by compressing the spring by means of a jack operated by pilot's throttle lever.



VANGUARI
READY

First *Vanguard* main-stage engine has been shipped from General Electric Co., Evendale, Ohio, to Martin, Baltimore. For about one year GE engineers have conducted exhaustive tests leading to numerous modifications. Early burnout problems have been licked, and the engine now is ready for production, with only minor alterations. This picture clearly shows control and pump system details. The two engineers are adjusting the gimbal mounting.

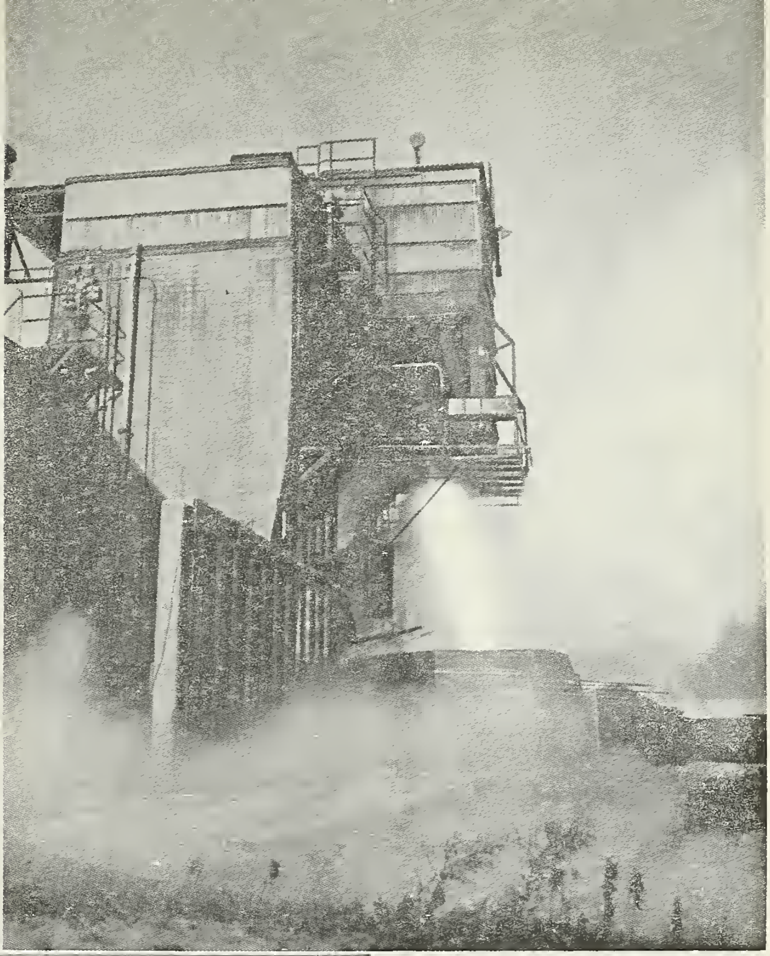


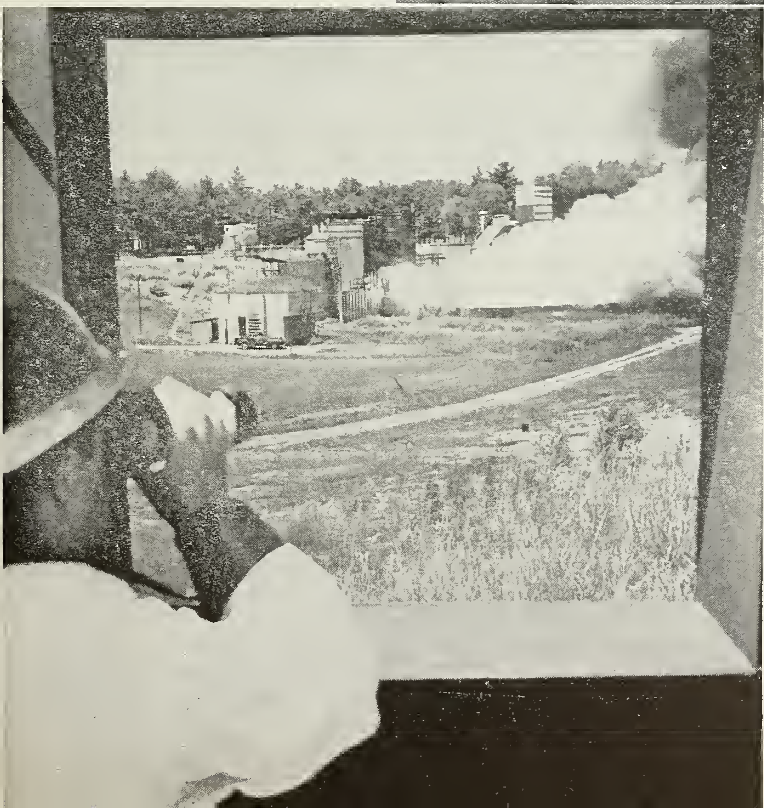
General Electric *Vanguard* main-stage engine developers discuss features of the re-designed injector head, heart of the powerplant. From left to right, Louis Michelson, Rocket Engine Section Manager; George L. Macpherson, X405 Project Manager; Benson Hamlin, Special Assistant to Rocket Engine Section Manager; and Fred I. Brown, Rocket Engine Sales Manager. *Vanguard* engine combustion chamber on table.

Technicians in the firing station at countdown. Original requirements called for 141-second burning period. At recent tests the engine has performed perfectly, burning time having exceeded 150 seconds. With a thrust yield of 27,000 pounds, the *Vanguard* first-stage engine will propel the satellite vehicle to a velocity of 4,000 miles per hour.

ENGINES
TO GO

GE's *Vanguard* engine under static run at company's Malta test station. Engine designation is X405. Because of early burnout problems, injector head has been redesigned; gasoline was dropped as fuel. Propellant combination used is special kerosene mixture with liquid oxygen as oxidizer.





Control engineer looks at engine through observation window at remote firing station. Developed by GE's Flight Propulsion Laboratory Dept., Evendale, Ohio, the powerplant now is scheduled to go through evaluation tests both by Martin, Baltimore and the Navy. Several actual flight tests will be conducted at Patrick AFB later. The first-stage engine is designed to carry the 11-ton *Vanguard* vehicle to 36 miles altitude.

How to boost RESEARCH and DEVELOPMENT efficiency

By Commander George W. Hoover, USN

RESEARCH and development throughout the country, although certainly productive, is capable of far more positive results. This can be achieved—not necessarily in the form of faster progress—but by making larger steps with fewer blind alley encounters.

Research and development has been too closely associated with the "ivory tower" concept, or with the idea that there is something strange and mysterious about trying to solve a difficult problem. There is also the idea that unsuccessful attempts to solve a problem are positive results rather than negative because in the process one more wrong approach is eliminated. This attitude is not only expensive but indicates poor planning.

There is considerable discussion about the wonderful progress that has been made in aviation in the last 35 years. In some branches this progress is not given enough credit. In others it is questionable.

These statements are not made to criticize the efforts of engineers, but to point out that the growing complexity of our aircraft and missiles indicates that our methods themselves need a little researching. There are many factors contributing to limited productiveness, but a predominant one is the influence of *inhibited thinking.*

Inhibited thinking is a scientific sickness which stems from being so saturated in knowledge that we "cannot see the forest for the trees." However, inhibited thinking has many known causes and is therefore a curable disease. One cause of this knowledge-bound thinking is the lack of imagination and the resultant loss of foresight.

Constant fear of ridicule from colleagues when there is any deviation from the accepted path or theory is another factor.

The overwhelming desire of individuals to become inventors also must be considered. In addition to the pleasant thoughts associated with receiving royalties and possible promotion, there is the inclination of an inventor to press his own ideas—sometimes to the exclusion of facts.

Furthermore, there is the threat of deadlines to be met and the continuous drive to cut costs. This is an emotional effect brought about by management's subtle reminder—no successful bids, no need for engineers.

The last and perhaps most important cause of inhibited thinking is the methodology employed in carrying out a major part of our research and development.

Fundamental Terms

Projects are started often without making a complete statement of the problem. This results in a partial solution which we justify by calling it a compromise.

Therefore we must think uninhibitedly and seek an adequate solution by stating the problem in its fundamental terms. To think in this manner we must treat each problem as a completely new one.

Many engineers today consider such tactics dreaming. Engineers seem to be objective in their thinking with their feet solidly on the ground. This is certainly a very healthy attitude if their feet don't get stuck too deeply in the mud.

Let us first define research and development and then try to apply this scientific approach to the problem of aircraft instrumentation.

Research is the systematic analysis of a problem consisting of stating the problem in its fundamental terms. Development is the application of these physical phenomena into practical and adequate solutions, not just modifications of an old idea.

By establishing a dual effort, the research is where the uninhibited thinking must prevail with a carry-over to the more practical aspects of the development. Such an approach requires two completely separate groups: one to determine the path, the other to follow it—both working together.

In applying this approach to the instrument problem, for example, we first state the overall problem. Fundamentally the instrument problem involves much more than just the design and development of a group of instruments for installation in a missile control station or an airplane cockpit. The problem in fact is one of creating a man-machine system, the efficiency of which is a product of both factors. The machine we can re-design, the man we cannot. Therefore we must start our analysis with the man.

Of all the sensory systems vision is the strongest in effecting orientation. This being true, it is essential in the man-machine problem to create a display which will not only be adequate but compatible with the other sensory systems.

To bring about a proper display it is necessary to sense cer-

tain phenomena. These data must be computed to produce the display.

Display Requirements

In order for the man to respond to the display a control system must be furnished. In addition there must be a means of communication both internally through signal transmission and externally through radiation.

The overall problem—and this applies to almost every type of research and development—falls into five areas: (1) Display, (2) Sensing, (3) Computation, (4) Control, and (5) Communication.

In the case of display for aircraft the primary question to be answered is simply "What does the pilot need to have displayed?"

There are actually two major requirements. These are position in space and geographical position.

Each of the two areas must be further divided into three types of display:

1. Orientation, which tells the man what he is doing.
2. Director, which tells the man what he should be doing.
3. Quantitative, which tells the man how he is doing.

In order to determine the details of these three types of display it is necessary to make a complete analysis of the Information Requirements. The operators must be interrogated to establish the fundamental information necessary to accomplish the task without interpolation or mental computation.

For example, during an air interception the pilot needs range information. The fire control engineers present this information in the terms in which they always define range—in miles and yards.

However, pilots need range data in order to know when to lock on, when to fire the gun or rockets and when to break. Fundamentally range must be indicated as a directory type of presentation to eliminate remembering at what ranges to lock on, fire and break away.

When the questioning reaches a point where the operator states that without data he cannot carry out the task, then X data is the fundamental requirement. These information requirements must be established for each phase of the task from beginning to end.

The next task is to select an adequate yardstick to determine the display requirements. In most instances the yardstick is merely that which is most natural. In the case of orientation, the visual world is the yardstick because pilots do a good job of flying when they have access to the visual world.

By using the visual world as our yardstick it is relatively simple to determine what causes us to react as we do throughout the various phases of flight.

The proof here for a display is by axiom rather than by evaluation. If it is true that we orient ourselves by our perception of the visual world it follows that our display must be adequate if it reproduces the same cues apparent in that world.

Sensing certain phenomena is essential to producing any display. In the past we have chosen to divide the problem into specific types of instruments such as flight instruments, navigation instruments, fire control, landing, engine, etc. As aircraft became more advanced, it became fashionable to include more than just the instrument and refer to the development as a "system." These systems each included sensors, amplifiers, computers, indicators, etc. and were developed for a specific type of aircraft. In stating the overall problem, it appears that each mode is in reality only a repetition of the other. If we solve one, we solve them all.

For example, the only real difference between landing and takeoff is the application of power. The equations are the same. The only real difference between rendezvous and air interception is that in the latter case we release the armament. The only difference between takeoff and rendezvous is the plane of operation. In the final analysis all modes of flight are only variations of navigation.

Necessary Sensors

From the information display requirements we can determine the following necessary sensors.

1) Inertia, 2) Air Density, 3) Temperature, 4) Fuel Availability and 5) Electromagnetic Radiation.

All of the equations related to the flight of any aircraft can be solved by using these five sensors with respect to time. Navigation is a function of velocity which is a function of acceleration. Fuel management is a function of fuel available with respect to time. Position, obstacles, weather, and landing path are some of the information requiring the use of some form of electromagnetic radiation. They are all variables in the equations of navigation and orientation and therefore fit all modes of flight.

Simple Computation

Further analysis of the display requirements establish the variations of the basic equations of motion which must be computed. Only the basic equations must be solved with varying rates and total time the only difference between modes of flight.

An example of this is the difference between rendezvous and air interception. In the rendezvous mode the rate of closure gradually approaches zero whereas in strike it is maintained at some constant optimum rate. The total time in rendezvous is longer than interception. The equations of flight path are fundamentally identical.

With these requirements our computer becomes a rather simple device for solving a relatively simple equation continuously with varying rates and time.

In summary it can be stated that when the fundamental requirements of any problem are established the solution to the problem becomes apparent.

If engineers will take the time to state the problem at hand in its fundamental terms, if they will stop inventing and seek a completely adequate solution, if they will look at the problem not as an entity in itself, but as part of a complete system, if they will work with operators and human engineers as a team, they will be thinking uninhibitedly. Then progress will be made, not in smaller increments, but in a continuous series of major breakthroughs.

END.

[Opinions expressed in this article are those of the author and are not to be construed as official or as reflecting the views of the Navy Dept.]

What Guides the Vanguard?

Minneapolis-Honeywell Builds Complex Gyro Reference System

By Henry P. Steier

A new milestone in the use of the gyroscope will be attempted when the *Vanguard* earth satellite vehicle takes off into space.

Job assigned to the gyroscope in this case calls for guiding an 80-foot rocket vehicle weighing 21,978.5 pounds to a very accurate orientation with respect to the earth.

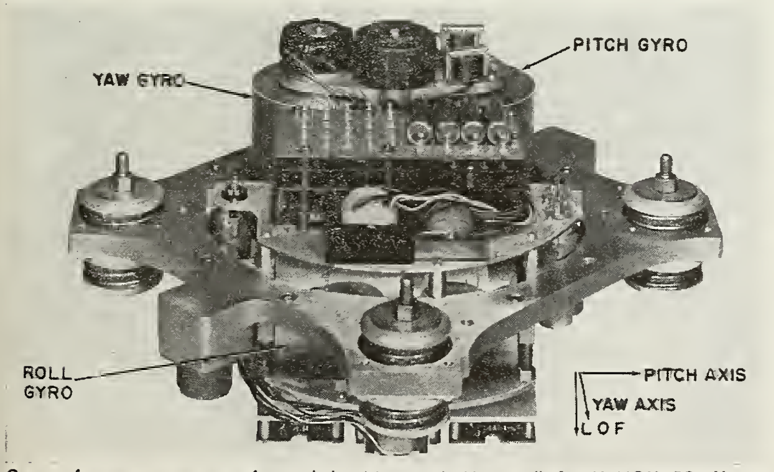
From a vertical position on the ground at takeoff to a horizontal position at about 700 miles from the launching point, a guidance reference system containing three gyroscopes and astrionics gear will tell *Vanguard* what to do and when to do it.

Chosen altitude for the satellite to be released from *Vanguard* vehicle is 300 miles. At the point where the satellite is released the third rocket stage that carries it must be oriented in pitch to an accuracy of 0 degree with respect to the tangent of the earth if the orbit is to be circular. If it is to be elliptical with a 300 mile perigee and a 1500 mile apogee, orientation must be within 2.9 degrees.

The "brain" that generates the commads to direct this imposing orientation job is being built by the Minneapolis-Honeywell Regulator Co.'s Aeronautical Division.

First of the *Vanguard* guidance reference systems has come off a pilot production line at M-H. It will probably be used in one of a series of preliminary rocket systems for test purposes.

Tests are expected to start in a few months at the Martin Aircraft Co.'s *Vanguard* test station being built in Florida. According to C. C. Furnas, Secretary of Defense, Research and Development, the program as it now stands calls for six preliminary rocket systems for test purposes to be followed by six complete rocket control and guidance systems for launching satellites.



Gyro reference system manufactured by Minneapolis-Honeywell for VANGUARD. Vector diagram in lower right corner shows direction of the three axis references. Shock mounts are located at the corners of the platform. Socket lugs for electron tubes can be seen near the center cut-out of the platform.

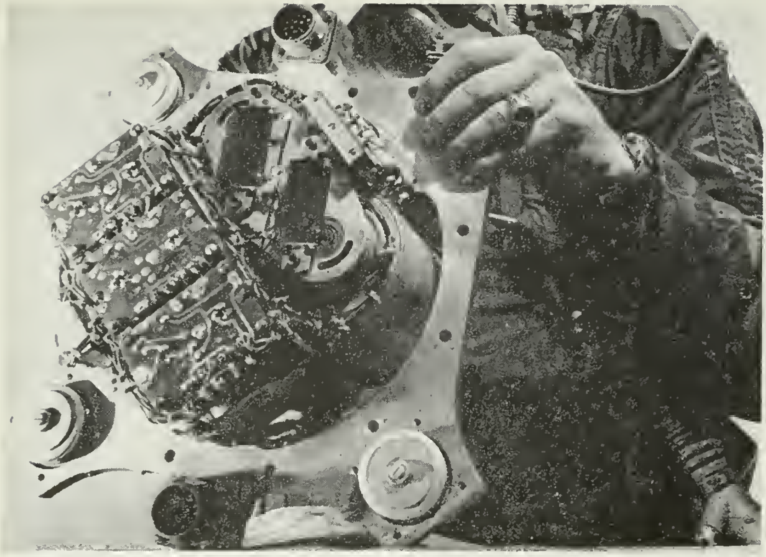
Guidance Program

The guidance system will operate during three periods of *Vanguard's* flight. These are the first-stage powered flight, the second-stage powered flight and the third-stage coasting flight. It will be located near the front of the second-stage rocket vehicle.

The program flight path calls for a vertical takeoff. After that a gradual tilting from the vertical to the horizontal will take place in the direction of the intended orbit. When the first stage burns out, the vehicle will be about 36 miles up and at about 45 degrees to the vertical. During this part of the flight, the M-H 3-axis gyro platform calibrated to control pitch, yaw and roll (line of flight) will command the vehicle.

Its job at the start will be to sense any movement from the vertical. This movement will be picked off the pitch and yaw gyros as an electrical signal. The signal will be sent to an autopilot amplifier. When amplified, the signal will be sent to the servo system that controls tilt of the gimbal mounted rocket thrust chamber at the rear of the first-stage.

This operation has been compared to juggling a broom on the finger. Roll gyro will sense line-of-flight roll that might be induced from sloshing fuel, wind or other forces acting on the vehicle.



Underside of the guidance platform showing two of the gyros and printed wiring boards that will be used for hook-up of the control circuits.

Correction for roll will be supplied by auxiliary off-on jets from the side of the vehicle. These will take their commands from the guidance system and be activated as needed.

While the M-H guidance system is mounted on a platform, it is not a true inertial guidance system. Through its shock mounts, the diamond-shaped platform will be fastened in a fixed position in the vehicle.

Gyros known as hermetic integrating gyros (HIG) will be used. A type made by M-H known as HIG-6 has been chosen for the job. This gyro contains, in a hermetically sealed can, a gyro wheel that rotates at about 12,000 rpm, a gimbal supporting the wheel, a torque generator for changing position of the gimbal, and a signal pick-off potentiometer.

The gimbal is floated in a fluid called Fluorlube. By carefully controlling the weight of the wheel and gimbal combination, its specific gravity is exactly matched to that of the fluid. In this way the bearing friction problem in gyros is reduced.

In a figuratively "weightless" condition, the gimballed gyro in a floated system needs a minimum of bearing surface. Jeweled bearings can be used since they act only as guides for the gimbal shafts and are small enough to be nearly frictionless.

Result is ultra-high sensitivity of the gyro to any movement. Its "memory," or desire to resist changes in gimbal movement is unrestrained by friction forces acting on it.

Variable Memory

Flight plan called for in *Vanguard* requires that the memory of its guidance system be changed in accordance with the maneuvers the vehicle is to make.

Three factors are important in getting *Vanguard* in the right position for establishment of the satellite in a satisfactory orbit. These are speed, altitude and angle.

To the pitch gyro with its supporting astrionics gear falls the very important job of easing *Vanguard* into the correct position for the satellite's kick-off into the orbit.

Shortly after takeoff a clock-like programming timer and accelerometer device will go into action to change the pitch gyro's "memorized" axis. This pitch programmer will cause a signal to be fed to the gyro's torque generator which causes rotation of the gimbal to a new position.

The new position will be picked off the gyro's signal potentiometer and fed through the guidance system to tilt the thrust chamber. As this happens the vehicle will tilt away from the vertical.

At about 36 miles altitude when the first stage burns out it will be separated from the vehicle and dropped. At this stage the guidance system takes over control of the second and third stages.

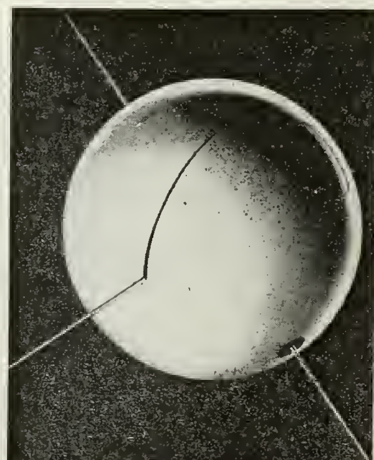
A gradually programmed tilt of the second stage thrust chamber will bring the vehicle to a steadily increasing angle from the vertical until at about 140 miles altitude the second stage burns out.

From then on the vehicle will coast to orbital altitude of 300 miles. It is during the coasting period that the most critical part of orientation takes place. Here the 0 to 2.9 degree parallelism to the earth must be finally achieved.

Control during this period will be transferred to an array of jet reactors. Signals from the guidance reference system will be fed to these to nudge the remaining portion of the vehicle into place.

By the time the coasting period ends at a distance of about 700 miles from the launching point the vehicle is fully committed. No further control of orientation can be made.

Both transistors and electron tubes will be used as part of the guidance reference system. Temperature controllers are used by M-H to keep the gyros at operating temperature through heaters built into the gyros. Six Honeywell H-6 transistors are to be used in an all transistor controller amplifier. It will perform both power and switching functions. No relays will be used because of vibration and shock problems. Tubes will be used for amplifying pick-off signals.



Eleven ton complex 3-stage rocket burning five different kinds of propellants and using intricate guidance is needed to push 20-pound satellite into space.

Astrionics

By Henry P. Steier

A close-up look at a much publicized and photographed "popular" model of an IGY satellite shocked viewers at the recent Instrument-Automation Conference and exhibit in New York's Coliseum. Resistors, capacitors, tubes and "things" aimlessly strung inside the plastic sphere in Christmas tree fashion did not make sense. Fortunately the Naval Research Laboratories' plastic model was nearby to offset any doubts about the project's sanity.

•

The *Terrapin* ionosphere research rocket developed by Republic Aviation Corp. and recently flown to an altitude of 80 miles is considered the cheapest and most portable rocket of its kind. Named after the University of Maryland's mascot, *Terrapin's* nose carried all-transistorized astrionics gear including printed circuits. A Geiger counter was carried to measure cosmic radiation. Dr. Fred Singer of the school's Physics Department, which developed the astrionics, said the instrumentation in *Terrapin* is "so simple" it was built by high school and university students.

•

Singer has set forth a proposal to measure micrometeorite erosion of the satellite surface by placing a radioactive tracer in a portion of the skin. A Geiger counter mounted beneath the skin surface would detect loss of material by erosion as a decrease in counting rate. Another proposal by H. E. LaGow of NRL would use evaporated nichrome film on glass to determine erosion through increase of resistance. Counter would, if practical as a payload, give accuracy badly needed in such measurements.

•

Westinghouse Electric Corp.'s redevelopment of the vibrating rate gyro may prove more practical than the attempted development of the same idea by others a few years ago. The "vibragyro" is another case of the applied science of engineering taking a clue from the pure science of biology. Certain insects use vibrating masses known as "halteres" (leaping weights) for flight stabilization. Mounted in a sort of tuning fork configuration on the insect's back and fastened to its nervous system the vibrating halteres respond to movement about the fork's vertical axis by producing an oscillating torque proportional to the rate of turn. Westinghouse's Air Arm Division is evaluating the latest version in an autopilot it makes.

•

Unsung heroes until last month were the USAF ground-based radar specialists. In a move to provide recognition to the previously unheralded radar controllers on the ground who advise interceptor pilots on the location of moving targets, the Radio Corp. of America awarded individual and division trophies to winning USAF intercept teams competing in the air-to-air rocketry events at Vincent Air Force Base, Arizona on October 18. The former Yuma AFB was officially dedicated as the Vincent AFB at that time. The RCA trophies will be awarded yearly.

The Missile Control Problem

can electro-hydraulic servo systems solve it?

By Jordan E. Johnson

MOST practical approach to missile control is generally conceded to be the use of electrically controlled hydraulic servo systems.

The limited life of a missile has given impetus to the design of very small accessories possessing a high degree of reliability. Because of the short life requirements, accessory manufacturers have been able to utilize hitherto unexplored design techniques in producing unusually compact, lightweight units capable of consistently high performance and reliability.

Reliability is at the top of the list of missile control system requirements because of the "one time" nature of the application of this type of craft. Missile system operation must be right the first time; there is no second chance in the event of system failure.

In most missile applications, weight and space is at a premium. Research programs are geared to strive constantly for more compact, lighter weight missile components. Increased power/weight and power/size ratios usually are the goals.

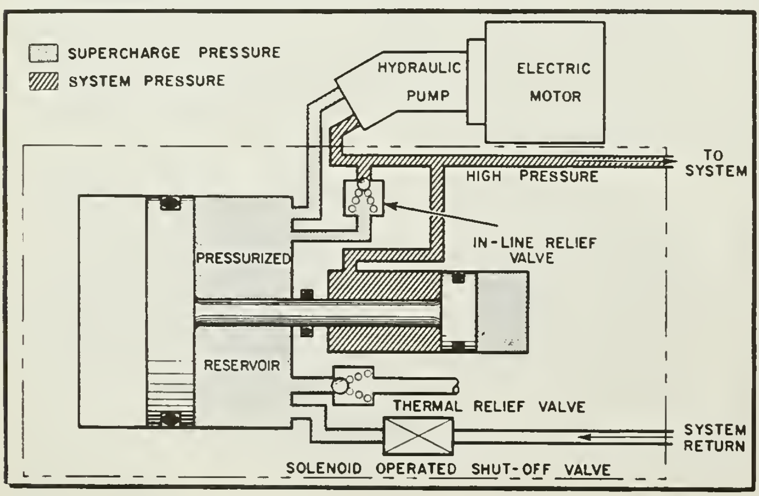
In this regard, high overall mechanical efficiency assumes greater importance because of the resultant minimum power loss. High mechanical efficiency improves power/-weight and power/size ratios and reduces in-flight power drain.

In a system powered by a storage battery, for example, a given battery will be capable of powering a longer flight; or a smaller size battery of lower power rating may be substituted to reduce further system size and weight.

An added requirement has been imposed upon missile systems by the logistic trend toward maintenance of larger supplies of missiles. With contemplated storage for periods of five years or more, missile control systems must possess not only reliability and high performance in actual operation, but unusual shelf life as well.

Missile operation covers a broad temperature range. Hydraulic pump selection, for instance, must be based on the worst possible condition. For this reason, a pump having virtually "flat" temperature characteristics is to be preferred because of the size reduction automatically achieved.

Schematic drawing of packaged hydraulic power source. Pump discharge (system) pressure is directed to small piston causing it to tend to move to the right. Large piston, on common connecting rod, moves in same direction thus pressurizing pump inlet line. In-line relief valve controls maximum pressure and thermal relief valve protects against excessive temperature rise in missile during ground preflight operation.



Where an oversize pump must be used to compensate for reduced performance at elevated temperatures, a vicious efficiency loss cycle is started. The larger pump at lower ambient temperatures produces excessive flow, which raises fluid temperatures, thereby diluting the pump's efficiency and creating the need for a larger one.

Temperature effect on the relief valve setting also must be considered. No appreciable pressure setting sag can be tolerated. Similar considerations apply to all missile hydraulic components.

Packaged hydraulic systems have many advantages to offer—small envelope, reduced weight, minimum of plumbing, simplicity of installation and ease of maintenance. They permit assignment of responsibility for design, manufacture and performance testing to a single reliable source.

This single-source concept insures maximum compatibility of system components, thus simplifying trouble shooting procedures and avoiding a potential trouble source brought on by the inter-action of mismatched components.

Vickers Inc. has developed a packaged missile system of the "plug-in" type. When fitted with self-sealing quick-disconnect fittings, the package can be quickly and easily installed or replaced. Detail troubleshooting therefore can be confined to the bench.

A typical packaged hydraulic power source suitable for missile installation is made up of an electric-motor-driven, miniature, fixed displacement pump mounted to a manifolded valving assembly.

These manifolded valves include a standard in-line relief valve, a solenoid shut-off valve and a thermal relief valve; also, a spe-

cial, self-pressurizing reservoir matched to the pump inlet pressure and system's fluid capacity needs.

The components used in this package have been tested at elevated temperatures and under severe vibration conditions.

The package is provided with self-sealing fittings for quick connection to the electro-hydraulic, surface control servo system. Primary power in this particular instance is derived from a storage battery. It is quite possible, however, that a ram air turbine, air motor or monopropellant turbine might be substituted for the electric motor in some installations.

The pump used in this typical missile hydraulic power package is a miniaturized version of the Vickers fixed displacement piston unit.

Overall mechanical efficiency when operating at rated speed and pressure exceeds 92 per cent. Volumetric efficiency is approximately 98 per cent. This higher efficiency permits use of a smaller storage battery and related equipment for giving missile applications.

Pump output does not vary appreciably with temperature change, and efficiency loss between normal operating temperatures and 258°F is less than 3%. Therefore, it is unnecessary to over-size the pump at low temperature to insure sufficient flow at elevated temperatures,

Missile pump weighs only 0.9 lbs. delivers 4.3 hp.

In-line relief valve . . .

neither is it necessary to provide a warm-up period. This basic Vickers pump design is approved under Spec. MIL-P-7858.

The in-line relief valve design combines unusually accurate control and fast response with exceptionally "flat" performance characteristics. This component has been vibration-tested in all axes at frequencies from zero to 2,000 cps. Amplitude was such as to produce 25g's acceleration with no malfunction. High temperature runs up to 560°F have been most successful.

The self-pressurizing reservoir used in the package is designed to provide the optimum supercharge pressure required by the electric-motor-driven pump.

The reservoir design utilizes pump discharge oil at system pressure to maintain optimum inlet pressure independently of altitude, temperature and reservoir level. The pressure characteristics are perfectly "flat."

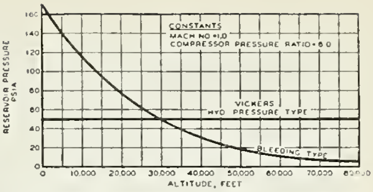
Since this is a "boot strap" operation, using pressure produced to maintain pressure required, spring loading of the piston is avoided and pressurization is initiated only when called for by the system.

This means that during extended stowage periods, the system will remain intact, without leakage or other deterioration. The Vickers pressurized reservoir may be made compatible with all known types of fluids over a temperature range of 65°F to plus 350°F.

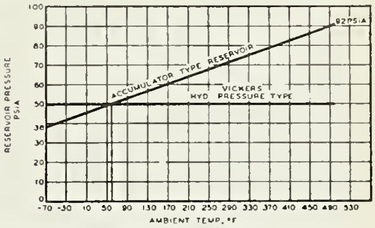
The Vickers packaged system concept for missile hydraulics is a simple and effective method for achieving design goals. Weight, size, performance and reliability are improved by the manifolding of valves and integration of the manifolded assembly with the pump and pressurized reservoir. In addition, shelf life characteristics are improved by the self-pressurizing "boot strap" type reservoir.

Research programs are continuing the search for lighter and smaller components without the sacrifice of performance and reliability. Higher temperature applications at higher speeds are being tested and promise to permit early revision of specifications that impose more stringent requirements.

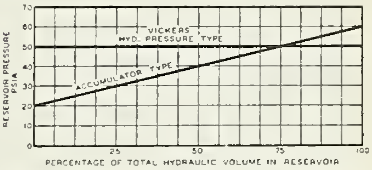
And the components utilized in



Comparison of pressurized reservoir and bleed-air type reservoir assuming no controls on bleed pressure.



Ambient temperature characteristics of hydraulic reservoirs.



Performance of pressurized reservoir and accumulator type reservoir for various oil capacities.

How Vickers self-pressurizing reservoir compares with other types. Note "flat" pressure characteristics for all altitudes, temperatures and reservoir levels.

the example power source package do not constitute the limit of those available for missile application. Another useful accessory is the hydraulic-powered electrical power package.

This unit is a further application of the package concept. It is a constant-speed hydraulic motor-driven alternator assembly. It is designed to supplant a conventional, bulkier inverter in providing a-c power. Speed control is within ± 2½ percent regardless of load. Special configurations will maintain 400 cps frequency within ± 0.1 percent, regardless of load.

These new units are available in six sizes for 0.5 to 3.0 kva output. Weight of the individual units is from 7 lb. for the smallest package to 19 lb. for the 3.0 kva output size. Special larger sizes up to 9 kva are being tested.

A subsystem such as this, complete within itself, makes the job of the missile project engineer easier and fixes firmly the responsibility for both performance and reliability with a single subcontractor.

Aerophysics

By Seabrook Hull

Operational intercontinental ballistics and glide missiles already may be in prototype stage. Effort is toward optimum, not desperation designs. Intensive physics research of high temperature gas dynamics and critical thermal properties is beginning to yield definitive knowhow.

Take a 2,500-mile ICBM initiating re-entry at Mach 18 with 10,000 lbs/ft^2 nose pressure; 12,000°F boundary layer temperature; and a 1,000 BTU/ft^2/sec average heating rate for 20 seconds. A warhead skin of thick copper for fast heat conductivity and primary heat sink capacity, plus a thin platinum alloy coating for chemical stability and over 95% reflectivity might make addition of deadweight coolant, such as water, unnecessary. Holding maximum skin temperature to 1,500°F design target indicates need for high drag-to-weight ratio nose cone (hemisphere) to slow re-entry speed early and average out heating rate. Future high-temperature materials to cope with 10,000 BTU/ft^2/sec heating rate just before impact will facilitate cutting heat-sink weight and enable switch to faster-falling, low drag-to-weight ratio tapered nose cone.

Glide bomber technology centers on thermal equilibrium of mission flight conditions—2,500-mile range, Mach 12, 150,000 ft and ram air pressure of 300 lbs/ft^2. Resulting 9,000°F boundary layer temperature over sharply swept delta gives a 5 BTU/ft^2/sec average heating rate for 20 minutes in the laminar flow forward wing area. Radiation away equal to heat input occurs at skin temperature of 1,600°F. Equilibrium in the turbulant boundary layer across the aft wing occurs at 2,500°F. Proposed wing cross-section shows red hot inconel outer skin separated from inner steel structural skin by a layer of thick insulation.

Steam from supplementary cooling in leading edges, where heating rates hit 50 BTU/ft^2/sec and equilibrium temperatures exceed materials limits, could power control/guidance gear. These two concepts are heavy and primitive but would work, though the cost in massive firing stages would be vast. Materials to stand 3,000°-to-5,000°F are badly needed in order to reduce final missile weight.

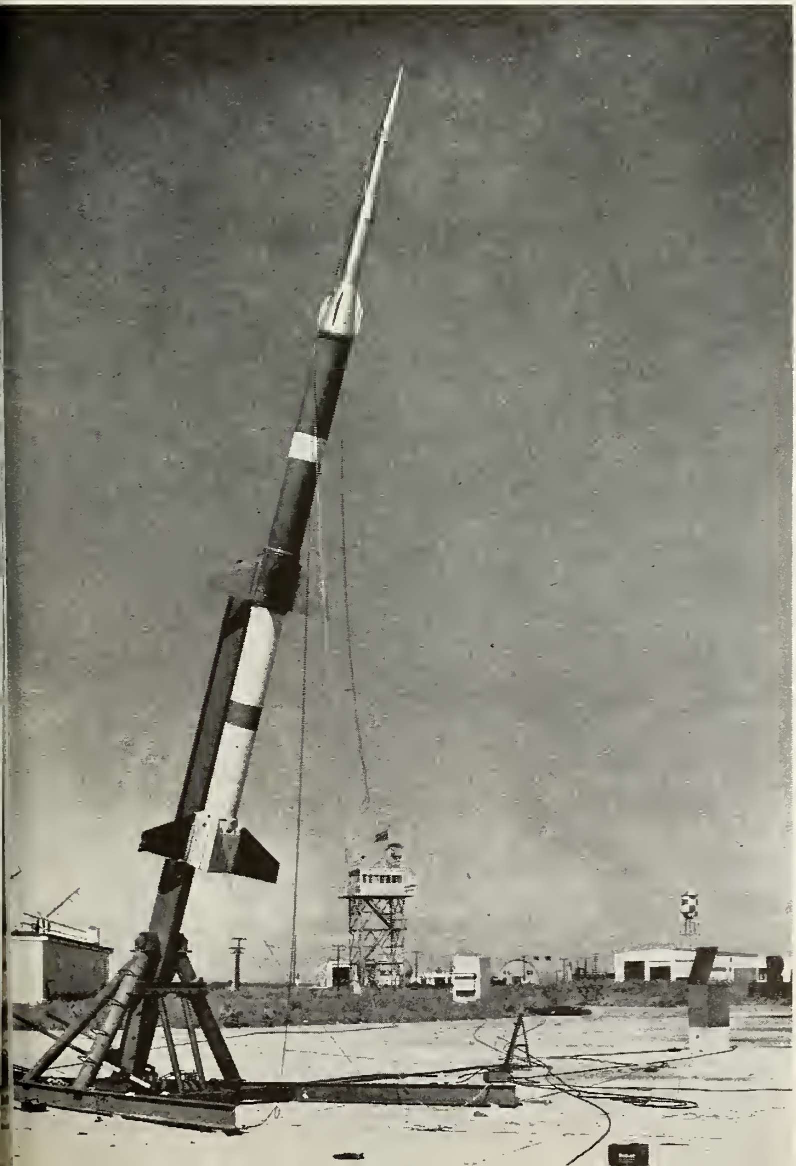
NACA is developing rate controlled stability and guidance system to make up for lack of oscillation damping in the space and near-space flight of manned vehicles . . . For some hypersonic devices (order of Mach 10) flared tail cones provide higher stability and less aerodynamic heating than conventional swept cruciform fins . . . NACA is flight testing materials to temperatures up to 7,000°F . . . Air Research and Development Command's latest "Tables and Graphs of the ARDC Model Atmosphere, 1956" (replaces NACA TechNote 1200) gives atmosphere data to an altitude of 330 miles; is being printed by Cambridge Laboratory.

NACA boosts rocket research

200-mile altitudes 7,000 mph speeds

A four-stage research rocket assembled by the National Advisory Committee for Aeronautics has attained a velocity of Mach 10.4 (6864 mph), an altitude of approximately 200 miles and an estimated range of about 500 miles.

This was disclosed by NACA last month during the Triennial Inspection of its Langley Aeronautical Laboratory. The record flight took place about two years ago at NACA's Pilotless Aircraft Research Station at Wallops Island, Va. Its disclosure at this time suggests that far greater achievements have taken place during the interim period which the government is not willing to discuss yet. At least one is the recent firing of a *Redstone* assembly for a record 3000 miles. (See page 33)



The four-stage NACA rocket measured 35 feet, 8 inches in length and weighed a total of 2800 pounds. First two stages were finned Nike boosters, each 11 feet long. Third stage was a finned Thiokol T-40 rocket 4 feet, 6 inches in length; the fourth was a flare-stabilized Thiokol T-55 which measured 6 feet in length with instrumentation.

The assembly was launched over the Atlantic from Wallops Island after the area had been cleared by a Navy air search. The stages were fuzed to permit a brief time lag between the burning of one stage and the firing of the next. This was done to avoid excessive heating in the lower atmosphere.

Maximum speed was attained at an altitude of 84,000 feet, when the last of the four stages was exhausted. The fourth stage, together with its cargo of thermocouples, accelerometers and telemetering equipment, coasted from that point to an altitude of more than one million feet. Although its fall into the Atlantic was not observed, its velocity and trajectory indicated a range of approximately 500 miles.

Extreme range is definitely not one of NACA's objectives in conducting the aerodynamic heating research program. To minimize this feature of its high-speed rockets, it has developed an "over-the-top" trajectory in more recent firings. This involves burning the first two stages

NACA 4-stage research rocket ready for launching.

on the upward portion of the trip and delaying ignition of the remaining two stages until they reach their peak altitude and begin to descend.

Even with this technique, however, horizontal ranges of 60 to 100 miles are regularly achieved, according to Robert L. Krieger, Engineer-in-Charge of Wallops Island.

NACA is presently using a souped-up four-stage rocket vehicle at Wallops Island which employs an *Honest John* as the first stage. The other three stages are identical to those of the earlier models. It is 41 feet in length and weighs 5700 pounds when loaded. Use of the bigger first stage unit provides the valuable addition of two seconds of firing time and thus permits the entire assembly to reach an appreciably higher altitude.

This, in turn, means that substantially greater velocities—possibly bordering on those faced by re-entering ballistic missile warheads—can be achieved for the final stage of the assembly upon its plunge into the denser layers of the atmosphere.

NACA's high speed vehicles are providing considerable data on nose cone re-entry problems for ballistic missiles, but an equally important project is the accumulation of information on the behavior of small aircraft models at super-speeds. This is of particular significance to the hypersonic rocket glider which would obtain its initial impetus from rocket boost to great altitude and then rely on the aerodynamic lift of its wings to coast to its destination.

"This type of vehicle appears to be the one most suited for man-carrying wherein we may set as our goal the effective shrinking of the size of the earth so that any two points on it are only a short day's journey apart," said F. L. Thompson, Assistant Director of Langley.

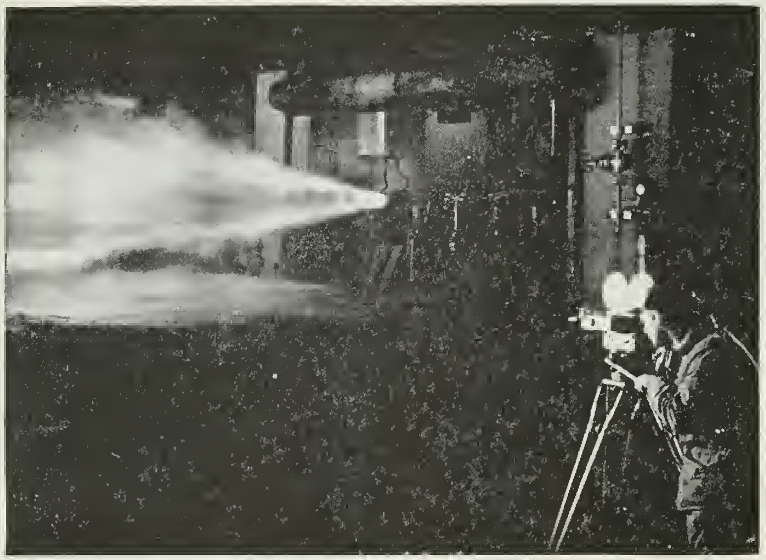
Chief advantage of solid-propellant research vehicles is their low cost and ease of handling compared with liquid-propellant rockets, according to NACA technicians. "We can set up one of these solid rocket assemblies, check out all the equipment and be ready to go in three hours," one official noted. The cost advantage is also substantial. NACA paid a total of about $7500 for its earlier four-stage rockets, exclusive of modification and instrumentation. Liquid-propelled rockets carry a

NACA shoots stage-rockets using current hardware in different combinations.

price tag of $35,000 and up.

NACA also described some of the work by Lewis Flight Laboratory near Cleveland on the problems of "chugging" and "screeching" in rocket combustion chambers. These are low and high frequency oscillations in the flame front inside the chamber. Even a mild oscillation can produce pulses with a force of five tons against the sides of the rocket chamber, while more rapid vibrations accelerate the heat transfer rate by as much as four times, with the result that the engine is quickly and spectacularly destroyed.

Chugging can probably be eliminated through improved design of the propellant system, but no general solution may be found for screeching, which takes a variety of forms. Motion pictures of the screeching phenomenon, taken at the rate of 47,000 frames a second, disclose three separate movements within transparent lucite combustion chambers: transverse oscillations from one side of the chamber to the other, longitudinal oscillations from one end of the chamber to the other, and rotary oscillations around the longitudinal axis of the chamber.



NACA rocket engine under static test.

Simple NACA model to check operation of a new multi-rocket booster.

Research vehicle to obtain data on jet vane in booster exhaust.

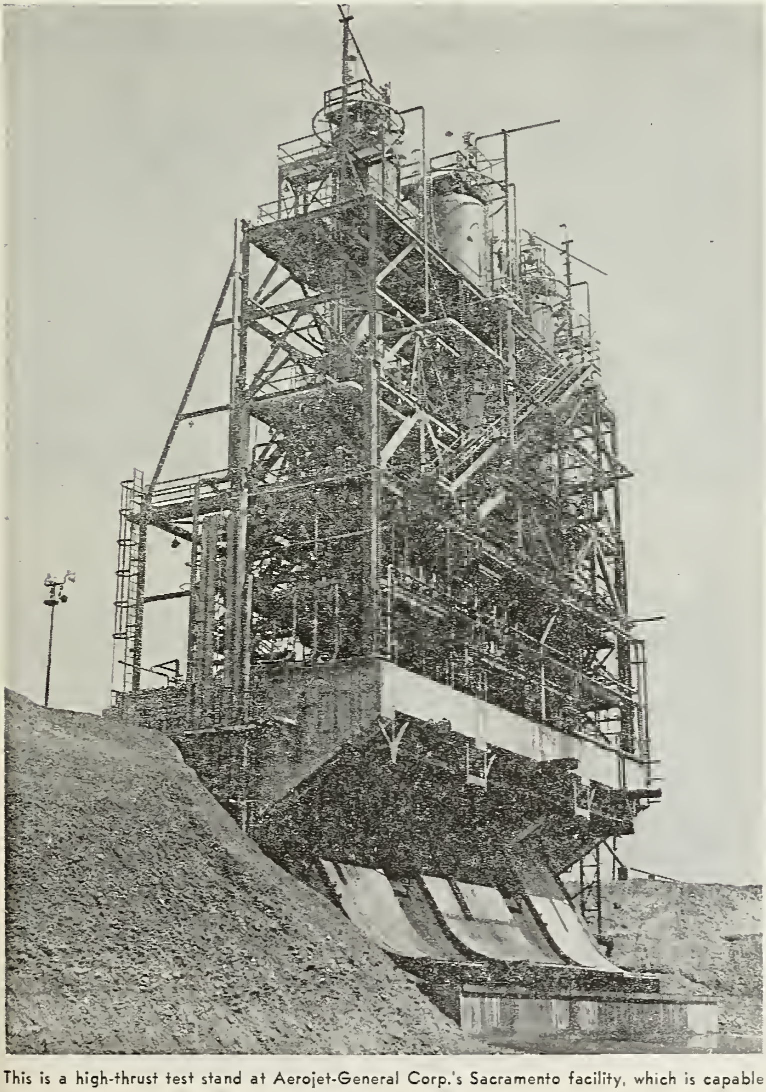
In addition to photographing the shock fronts which occur during screeching, NACA uses pressure-sensing devices to measure their force and an ingenious method to record temperature variations. Sodium, which ionizes at a known rate in terms of temperature, is added to the propellant. A micro-wave signal transmitted through the rocket chamber is altered by the variations of sodium ionization so that an accurate record of the temperature of the shock fronts during screeching can be obtained.

NACA employs a variety of other test facilities in its attack on the problem of aerodynamic heating. Among them are:

- A light gas gun at Ames Aeronautical Laboratory south of San Francisco which is capable of firing small models at velocities up to Mach 20. A small magnesium model fired in this tunnel reached a speed of 11,000 mph and ignited as a result of the tremendous heat.
- Combustion products tunnels at Langley, one utilizing a 2.5-inch rocket engine capable of velocities of 4750 mph and temperatures of 4100 degrees F., and the other using high pressure air heated to 3500 degrees F. in a combustion chamber and capable of 1300 mph.
- Quartz tube heat lamps capable of producing rapid, extreme and unsymmetrical temperature variations on wing and tail structures and other components to simulate the effects of uneven heating encountered in high-speed flight.
- Carbon rod radiator which can generate up to 4700 degrees at the rate of 100 Btu per square foot per second—equal to Mach 5.
- Blowdown tunnel incorporating a ceramic heat exchanger capable of producing a jet blast of Mach 5 velocity and 4000 degrees F.
- A system of windtunnels built under the Unitary Plan which can simulate air velocities ranging from Mach 0.7 to Mach 5. A new tunnel with a larger test section capable of subjecting full-scale components to velocities up to Mach 3 is expected to go into operation next year.
- Flight testing of rocket-powered research aircraft like the ill-fated Bell X-2. Work will continue with the Bell X-1-B and X-1-E at NACA's High Speed Flight Station at Edwards AFB, Calif.

ICBM Engines — *Ahead of Schedule?*

By Fred Hunter



This is a high-thrust test stand at Aerojet-General Corp.'s Sacramento facility, which is capable of testing rocket engines up to 1,000,000 pounds thrust. It is 84 feet wide, 65 feet deep and 100 feet high, including superstructure.

BULLDOZERS already had swung into action clearing the site when Dan Kimball, president of Aerojet-General Corp.—aboard a bright new tractor—officially broke ground for the new $13,000,000 Production Plant, which will be the latest addition to the company's rocket engine facility. The plant will be located on a 20,000-acre site near Sacramento, Cal.

To be devoted to the manufacture of big rocket engines for the Air Force's ballistic missiles program, the new Aerojet plant will be the twin to another $13,000,000 facility now nearing completion at Neosho, Mo. for operation by North American Aviation.

The Air Force originally intended to have Aerojet operate the Missouri plant. Subsequently, it was decided efficiency would be served by turning Neosho over to North American.

Flanked on one side by the $9,000,000 Solid Rocket Plant, which has been producing between 500,000 and 900,000 pounds of propellant per month since it began production in 1952, and on the other by the Liquid Rocket Plant, a research and development facility started early in 1955 to work on the ICBM program, the Production Plant embodies a manufacturing building 550 feet wide and 560 feet long. It will employ approximately 1200 workers in administration, inspection, machining, sheet metal work, welding, assembling, heat-treating, hydraulics, tooling and maintenance. Machine tools of approximately $5,000,000 value will be installed.

Maj. Gen. Bernard Schriever, commander of the Air Research and Development Command's Western Development Division, said

construction on the Aerojet Production Plant would be expedited to bring it into manufacture at the earliest possible date. The company has a production contract for rocket engines under the Air Force's program for long range ballistic missiles, which includes the intercontinental *Atlas* and *Titan* and the intermediate *Thor*.

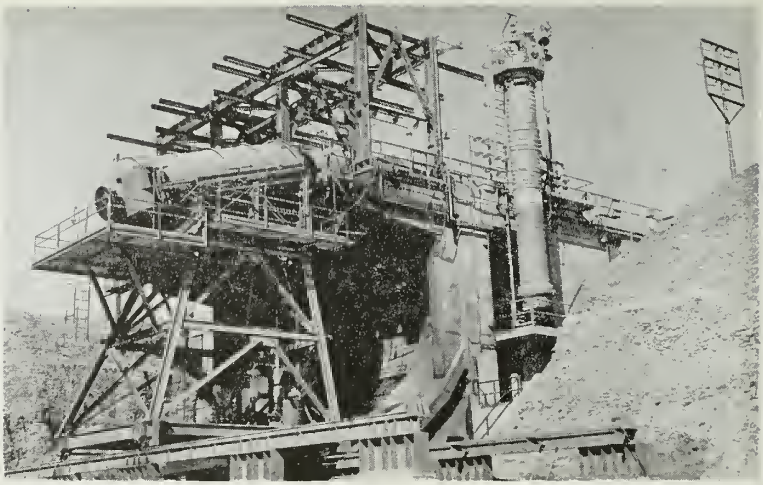
Aerojet has just marked up a record for itself in the speed in which it accomplished the installation of the test facility for its liquid rocket developments. The four complexes of two test stands each were completed in 18 months, or about half the time it ordinarily would take to complete an installation of this character.

Although only 15 miles from Sacramento, the area is isolated. The gold dredges which once mined the area have made thousands of acres useless for agricultural purposes, but an ideal location for the development and testing of large rocket engines. The test area has a buffer zone one mile wide around it.

The test stands range from 50 feet wide, 50 feet high and 67 feet deep to 87 feet wide, 100 feet high and 82 feet deep. They are located along a 40-foot deep ravine left by past dredging operations and their construction required the use of 11,807 yards of concrete. The largest stands are capable of taking up to 1,500,000 pounds thrust. All of the high thrust stands have three firing positions and employ large steel deflection plates which are cooled by spraying water at a rate of 5,000 to 10,000 gallons per minute in order to prevent erosion.

In addition to rocket engines for the big ballistic-type missiles, Aerojet uses its test facility to test rocket engines for other uses, such as for the *Bomarc* and second-stage *Vanguard*. Two high thrust stands for these purposes incorporate a superstructure design permitting a complete missile to be rolled up to the stand and titled into place for vertical firings.

Liquid oxygen is supplied by a mobile plant in the test area and a liquified gas plant under construction west of the Solid Rocket Plant. This facility is being constructed by the Air Products Co. under contract to the Air Force.



This photo of a test stand at Aerojet-General Corp.'s Sacramento facility shows how the concrete apron is protected by water-film-cooled steel plate which deflects the rocket exhaust during vertical test firings, protecting the concrete structure from blast erosion.

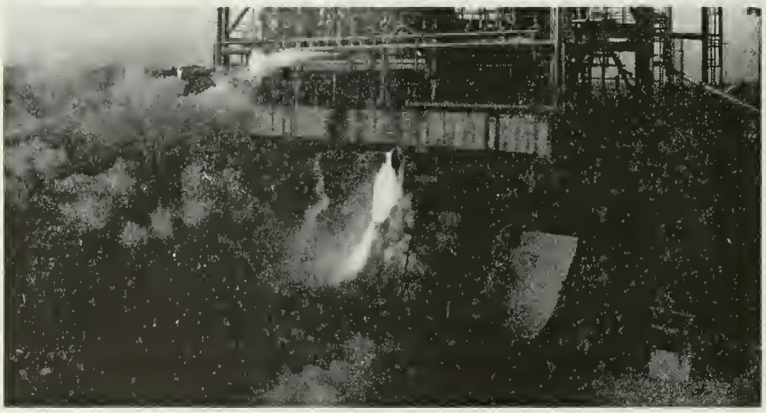


Photo shows test firing of liquid rocket engine in one of the high-thrust test stands installed this year at Aerojet-General Corp.'s facility at Sacramento.

This three-position, C-clamp type test stand at Aerojet-General Corp.'s Sacramento plant is used in development test firings of thrust chambers and ejectors. Each firing position has a 300,000-pound thrust rating.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Noble Metals for Guided Missiles

Already there is talk of using *platinum alloy-clad copper* to enable the ICBM warhead to cope with the intense heating of re-entry. Some of the pointed nose cones of the satellite launching vehicles may be platinum at the very tip.

Platinum is an important contender, too, as one of several simultaneous cladding materials needed to make molybdenum oxygen resistant for high temperature operations.

These uses are being compounded on top of the sharp increase in demand that has resulted in the last few years from rising consumption by the electronics industry, where it is used to build greater reliability and accuracy into electrical contacts, etc.

The platinum group consists of platinum, palladium, iridium, rhodium, ruthenium and osmium. As they are members of the same family in the periodic table they are quite similar in many ways. Their differences, however, serve the very useful purpose of supplying the qualities of one to another through alloying.

Their basic advantages are: chemical stability; a very shiny natural state, thus high reflectivity (95-98%); high melting points; relatively low vapor pressures; high strength and ductility; relatively low coefficients of thermal expansion.

At normal high temperatures, the platinum group metals do not oxidize. Platinum, for example, is used with induction heating elements at temperatures over 2,000°F.

At higher temperatures, oxidization is liable to occur, but it is at a very small rate and usually the oxide is stable only over a small temperature band, decomposing or vaporizing away once that band is left. It always leaves a shiny highly reflective surface.

Between the members of the group, hardness, strength, ductility, etc., vary. But when used in small amounts, one with another, properties can be altered pretty much to suit the metallurgist's wishes.

This is fortunate because only platinum and palladium occur in any appreciable quantities.

What isn't known too well about the platinum metals is how they perform under critical, ultra-high-temperature conditions. There is some possibility that one or more of these materials may suddenly become highly unstable if submitted to too high a heating rate or simply to too high temperatures and pressures in an oxygen-nitrogen atmosphere.

Critical properties of this nature are the subject of intense research by those now concerned with very fast, very high aerodynamic heating such as that encountered at hypersonic speeds in the denser atmosphere.

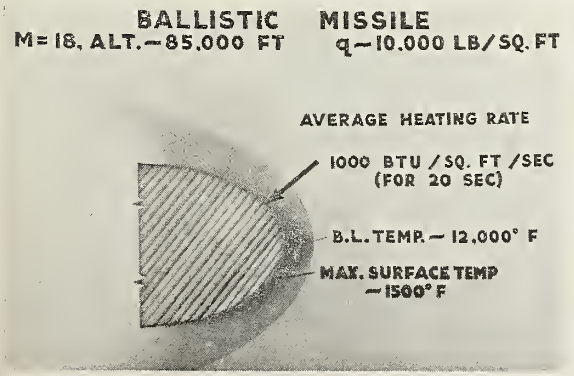
In a way this is unfortunate, for they are both expensive and rare. Production and sales are figured in ounces instead of pounds or tons.

Up-to-date figures on total world production are not yet available. It takes Washington about two years to catch up on mineral output and trade on a global basis.

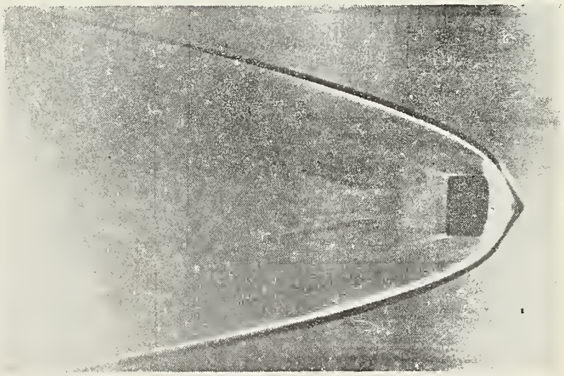
However, output—and U.S. imports—has been rising for some years, and probably hit 1-million fine troy ounces in 1955. The total for 1952 was 675,000 ozs. and in 1953, 750,000.

In 1955 the U.S. imported 1,009,819 ozs., up sharply from 601,612 ozs. in 1954. Part of this undoubtedly came from stocks on hand, part from new production. You get a good idea of how un-strategic the U.S. position is in these metals when you realize that domestic output in these two years was 61,481 and 56,766 ozs. respectively.

For platinum, palladium, osmium, ruthenium, iridium and rho-



NACA demonstrates thermal design limits of typical high drag-to-weight ratio ICBM warhead.



Heating problems of ICBM reentry is demonstrated by luminosity of gas around nose.

dium supplies, we are 90% dependent on foreign sources. Fortunately, neighbor Canada is one of the world's largest producers with a total of nearly 296,000 ozs. in 1953.

The Union of South Africa is the world's other largest producer with 296,000 ozs. Between the two, they account for over 90% of the total free world output.

Since the war, information on Soviet production has been non-existent. They have been estimated at 100,000 ozs. a year, but may have been much larger. Red natural resources are thought to be the largest in the world.

And lately, Russia has been offering metals of the group for export in trade agreements with free-world countries—about 13,000 ounces per year per agreement. Some have bought more, however, and Britain, for example, purchased 30,012 ozs. in 1955. Fortunately, much of this is re-exported to the U.S. for stockpiling and use by industry.

Though Western estimates put Soviet reserves at only 4-million ozs., Russia still claims 80% of known world reserves, and the odds are these claims are probably valid.

Free world reserves of platinum metals break down something like this: Canada, 6.5 million ozs.; South Africa, 10 million; and 5.5 million scattered widely among a number of countries.

Including the 4 million estimate for Russia, the 25 million of ounces still estimated to exist in recoverable form in the ground, 15 million are platinum; 7.5 million, palladium; and 2.5 million iridium, osmium, rhodium and ruthenium together.

One catch in this picture is the fact that most production now is as a by-product of mining nickel and copper (Canada) and of gold and silver (South Africa). Only Russia is known to have substantial, economic deposits of placer deposits. And any major increase in free-world output solely for the purpose of extracting platinum would result in a material increase in the cost.

And they are already expensive with platinum running some \$80-to-\$120 an ounce depending on market conditions; palladium, \$19-to-\$24; iridium, \$90-to-\$135; osmium, \$80-to-\$140; rhodium, \$118-to-\$125; and ruthenium, \$45-to-\$65.

An important and saving feature of this picture from a strategic point of view is the fact that these metals don't disappear. They are stable chemically and in the majority of uses they are put to, they are 100% recoverable.

Such stocks, excluding the stockpile (platinum and iridium are being strategically stored by the government), must now total several million ounces. In wartime, these could be requisitioned if needed.

But it's still not a lot in the face of sharply rising demand. Ten million ounces, for example, sounds like a lot, but a slide rule will quickly tell you it adds up to only about 350 tons.

Bell Executive Forecasts Increased Rocket Spending

U.S. spending for rocket procurement and development will probably reach \$1.25 billions over the next five years, Leston P. Faneuf, Bell Aircraft Corp. president, predicts.

Addressing the recent Buffalo, N. Y. meeting of the American Rocket Society, the Bell executive made it clear that rocket propulsion is now a full-scale industry—no longer just a sideline.

Faneuf said investments in rocket facilities over the past five years have run well into nine figures. Bell Aircraft alone has spent \$12 million on rocket instrumentation and production/testing facilities.

Bell's work now extends all the way from early development to high production, he concluded.

GE Establishes West Coast Propulsion Systems Unit

General Electric Co.'s Aircraft Gas Turbine Division has set up a California Advanced Propulsion Systems Operation in temporary headquarters at Danville, Calif. near San Francisco.

The new organization will take on the task of designing propulsion systems "both within and beyond the earth's atmosphere," GE officials say. And it will be free to employ any source or kind of energy engineers and scientists find adaptable to the system they design.

The company has optioned a 12-acre plot near Danville. If exercised, GE will begin as early as December with construction of a 7,000 sq. ft. facility to house some 75 engineers.

Overall direction of the propulsion group will stem from GE's flight propulsion laboratory department in

Cincinnati. However, the new west coast activity will not result in any curtailment of advanced propulsion research work at Cincinnati.

New Missile Facilities At Douglas, Northrop

Douglas Aircraft Co. and Northrop Aircraft, Inc. early this month added to their respective missile plant facilities some 133,000 sq. ft. combined.

Douglas took a 10-year lease on a 61,000 sq. ft. building at 11500 Tennessee St., West Los Angeles. It will be used for missiles engineering and missiles service and training.

Northrop leased an additional 72,000 sq. ft. at its Torrance, Calif. plant to provide more space at Hawthorne for *Snark* missile activities. Some 700 office and technical workers were due to occupy the new facilities early this month.

Regulus Powerplant Reordered

Allison Division, General Motors Corp. has received a contract totaling $1,503,200 for production of J33 jet engines to be used for Navy's Chance Vought *Regulus* I surface-to-surface missile.

Whittaker-Gyro Expansion Underway

History of the electrically driven gyroscope for airborne applications began in 1937 in a garage in Los Angeles owned by Leo Nevin Shivien.

Prior to that time airborne gyros were air driven devices. Large gyros for ground use were made by the Sperry Gyroscope Co. But Schivien's work is generally acknowledged to have been the beginning of practical application of the electrical driven principle to aircraft gyros.

During World War II the Schivien Engineering Co. produced gyroscopes for two glide bombs —*Azon* and *Razon*. Both were radio controlled and stabilized by Schivien's electrically driven gyros.

When the *Nike* missile was developed some of its gyros were made by the company Schivien founded and are still being made today by that company's successor.

The Whittaker Gyro division of Telecomputing Corp. in Van Nuys, Calif. carries on the work begun by Schivien. Schivien's interests were bought by the William R. Whittaker Co., Ltd. in 1954.

Whittaker Gyro is part of a growing organization that has been building up facilities for R&D and production in the missile and aircraft control mechanism, data processing, and electronic instrument fields.

Early in 1956 Whittaker and the Telecomputing Corp. merged. In August 1956, Telecomputing Corp. acquired Brubaker Electronics Inc. Brubaker became the fifth operating unit of Telecomputing Corp. Others are the Engineering Services division, and the Enterprise Development and Mfg. Co.

Telecomputing Corp. of North Hollywood, Calif. manufactures and develops semi-automatic data reduction equipment and business data handling systems. Brubaker produces precision electronic products such as delay lines, antenna filters, pulse transformers and laboratory test equipment. It is located in Culver City, Calif.

Engineering Services at Holloman Air Development Center in New Mexico operates the data reduction facilities there for handling optical tracking and telemetry data.

Enterprise Development and Manufacturing in Burbank, Calif. develops and produces special testing systems used by the Atomic Energy Commission for automatic control and data recording. The corporation received AEC telemetry contracts $1.5 million over the past 12 months.

AF Checks on Surplus

Air Force Air Materiel Command is screening about $5 million worth of heavy duty electronics and communication equipment stored at depots throughout the country to segregate current from surplus stock.

One phase of the inspection program is to determine the best approach to marketing highly specialized surplus electronic gear.

Program is under the direction of AMC's Materiel Redistribution and Marketing Division. Sales that may develop from the depot survey will be announced.

AEDC To Circulate Unclassified Reports

Air Force Arnold Engineering Development Center has launched a program to attain the widest possible industry circulation of reports on testing and test equipment.

First two of a series so far published are AEDC Reports TR-56-1 and TR-56-4. Subjects are "Online Automatic Data Reduction for Tunnel E-1 Gas Dynamics Facility" and "Investigation of a Multiple-Source Schlieren System for Application to a Perforated Wall Windtunnel."

Requests for these and future reports should be addressed to Commander, AEDC at Tullahoma, Tenn.

$26 Million For *Snarks*

NORTHROP AIRCRAFT, Inc. was assured continued developmental production of its SM-62 *Snark* intercontinental missile recently by a $26-million follow-on Air Force contract. *Snark* is powered by a Pratt & Whitney J57 jet and has a range of about 5,000 miles.

AMC Production Official Cites Rising Materials Costs

At the present rate of critical materials consumption in the U.S. for newer aircraft and missiles, conservation of certain of these materials has become essential, according to Air Materiel Command's deputy director of production, Brig. Gen. C. H. Mitchell.

And what is more, he told the recent National Industrial Conference in Phoenix, the situation promises to get progressively worse with attendant increases in cost of materials.

The next generation of aircraft, he said, will be composites of steel, titanium, aluminum, ceramics and high-temperature non-metallics—all needing development of methods for producing, forming, joining, contouring and assembly.

The AMC official cites these comparative costs per pound:

Aluminum	$ 0.35
Stainless sheet	$0.73 to $ 0.87
Titanium alloy	$20.00

For newer engines such as nuclear powered types prices run higher:

Lithium	$11.50
Reactor grade zirconium	$23.00
Beryllium (unfabricated)	$71.50

Materials costs are rising for two reasons, he added, scarcity and difficulties of fabrication. For example, he points out that it takes 3,000 lbs. of metal to produce 650 lbs. of finished discs for one jet engine. Such low utilization rates increase material costs alone to $60.00 per lb., Gen. Mitchell said.

Bendix Acquires Interest In Canadian Electronics Firm

Bendix Aviation Corp. has acquired a 40% interest in Computing Devices of Canada, Ltd. of Ottawa, an electronics firm which will market Bendix electronic and missile components.

Deal was arranged through its Canadian subsidiary, Bendix-Eclipse of Canada, Ltd. It calls for a sales and licensing arrangement whereby the Canadian firm will handle Bendix products.

Earlier, Bendix bought a 70% interest in another Canadian firm, Aviation Electric Ltd. of Montreal. It serves as an outlet for the company's electrical and mechanical aircraft components.

IAM Approves Raytheon Contract

International Assn. of Machinists has ratified a three-year contract with Raytheon Mfg. Co. at Waltham, Mass. calling for total wage increases of 41¢ an hour. Other benefits provide an eighth paid holiday, 10 and 15% shift differentials and an emergency wage reopener clause.

An immediate raise, retroactive to June 1, involves increases from 14¢ to 25¢ an hour. Others become effective June 1, 1957 and 1958.

Company now holds contracts to build Navy *Sparrow* III and Army *Hawk* I missiles.

Northrop to Build Missile Test Cell

Northrop Aircraft, Inc. has awarded contracts for design of an enclosed check-out building and test cell that will house an entire tactical missile and its operational launcher.

New facility, to be built at its Hawthorne, Calif. plant, is intended to make possible a full missile check-out and test yet protect nearby personnel and facilities from the extreme noise levels these operations produce.

Contract for design and fabrication of noise control equipment went to Industrial Acoustics Co., Inc. of New York through its west coast representative Midair. Architectural and engineering contracts were awarded to Pereira & Luckman.

Project is headed by Z. E. Sheffner of Northrop's plant engineering staff.

Another Northrop facility nearing completion is a missile engine test cell that will accommodate a missile the size of its SM-62 *Snark* with wings removed. It is essentially a "double building" with one concrete structure built within another.

Northrop engineers say its mass is so great that other plant workers will hear no noise whatever when an engine is being run in the cell.

Sperry Rand Names Arizona Division

Sperry Rand Corp. has chosen Sperry Phoenix Co. as the official name of its new electronics production facility to be built in Phoenix, Ariz.

Actual plant construction, initially involving between 75,000 and 100,000 sq. ft. and costing more than $2 million, will begin soon on a 480-acre site north of Phoenix.

Pending completion of the new plant, Sperry will start preliminary manufacturing operations in January using 10,000 sq. ft. of leased space at the Arizona State Fair Grounds in Phoenix. The company is not planning regular employee recruiting programs until later next year.

Lockheed Contracts For Nuclear Facility

Lockheed Georgia Division has let a $1,151,000 contract for construction of a nuclear support laboratory building as part of its A-plane research center at Dawsonville.

Laboratory will house engineers and scientists from Lockheed's Georgia Division and will include a two-story office building plus two one-story wings. It will be situated on a 10,000-acre tract set aside for the multi-million dollar Air Force center.

Missile Gyro Firm Votes 200% Stock Dividend

Directors of G. M. Giannini & Co., producers of missile gyros and control components, have voted a 200% stock dividend subject to approval of California Commissioner of Corporations.

Dividend is payable December 1 to holders of record November 15 and will increase company's common share holdings to 300,000. Giannini's present backlog of $5.6 million is highest in its history. It compares with $3 million in unfilled orders a year ago.

Convair Top Employer At Palmdale

Convair Division of General Dynamics Corp., builder of the *Terrier* and *Atlas* missiles, is now the largest contractor from the standpoint of employment at Palmdale, Calif., jet flight test center.

Convair payroll numbers more than 1,300; Northrop Aircraft is second with about 1,100. However, Convair is reported to be hiring at the rate of 50 each week and expects to employ approximately 1,800 by the year-end.

Litton Division Moves

U.S. Engineering Co., Inc., a division of Litton Industries, has occupied larger facilities located at 5873 Rodeo Blvd., Los Angeles 16.

Cooper Changes Name, Plans New Facilities

Cooper Development Corp., formerly Cooper, Inc., plans to construct a two-story office building and other production facilities at its Monrovia, Calif., location.

The company manufactures rocket and missile systems and holds a contract with Grand Central Rocket Co. for a rocket-motor unit for the *Vanguard* third stage.

Greer Forms R&D Group

Greer Hydraulics, Inc. of Jamaica, N.Y. has set up a new research and development division under v.p. Jules Kendall to develop and build prototype missile test systems.

New division has undertaken projects with Navy Bureau of Aeronautics, The Martin Co. and Farnsworth Electronics Co. on missile test systems and is also assisting in evaluation work on advanced rocket fire control systems.

Greer's work with Farnsworth was not disclosed, but presumably involves the Air Force's Boeing *Bomarc* supersonic surface-to-air missile. The Ft. Wayne, Ind. division of International Telephone and Telegraph Corp. is known to be developing a "push-button" go or no-go type test system for the ramjet and rocket-powered *Bomarc*.

AMF To Build New Lab

American Machine & Foundry Co. is planning construction of a $4-million central engineering laboratory on a 38½-acre tract at Stamford, Conn.

New unit will consolidate operations now situated at four locations in Greenwich, Conn., and one already in Stamford. No manufacturing is planned in the new facility.

New *Talos* Facility Gets Defense Nod

Navy has received approval of Defense Secretary Charles E. Wilson for a $4,440,000 expansion of facilities at the Naval Industrial Reserve Ordnance Plant, Mishawaka, Ind., for production of the *Talos* surface-to-air missile.

Plant is operated by Bendix Aviation Corp., prime contractor on the ramjet-powered *Talos*.

Norden-Ketay Plans Move

Norden-Ketay Corp. has begun construction of an executive office building on a 450,000 sq. ft. plot in Stamford, Conn. as part of a program to shift its offices from 99 Park Ave., New York City.

A second building, already in the planning stage, will house a central research laboratory for the company's missile activity. Contracts it holds in this field now exceed $5 million.

Pending completion of the new facility, the company has leased a building on Commerce Rd., Stamford.

Talco Commissions New Catapult Test Facility

A rocket-catapult for ejection of fighter pilots from high-speed aircraft has entered the test phase at Talco Engineering Co. of Hamden, Conn. Evaluation is being conducted at the company's new testing facility on a 23-acre plot at No. Branford, Conn.

Facilities at the new site include a 200-ft. horizontal track to handle large cartridge-activated devices and a 25-ft. track to test small units.

North American Gets $65-million Contract

North American Aviation, Inc. has received a $65,507,103 Air Force contract for continuation of research and development of undisclosed weapons systems.

NAA is known to have at least three major missile or rocket engine programs now underway. In addition to its own Navaho missile, the company is building liquid propellant engines for the Army's Chrysler Redstone missile and Convair's *Atlas* intercontinental ballistic missile.

Beckman Sales, Earning Up

Beckman Instruments, Inc., producers of missile test instrumentation, reported a 38% increase in sales and similar jump in earnings over 1955 for its fiscal year ended June 30.

Company's net after taxes was $1,744,856 compared with $1,322,050 last fiscal year. Sales were $29,362,131 against $21,330,598 for the year ending June 30, 1955.

Lockheed Again Expands Missile Division

Mushrooming activity at Lockheed Aircraft Corp.'s Missile Systems Division has resulted in a 1,000% expansion of space planned less than a year ago for its new facilities in Stanford University's Palo Alto, Calif. industrial park.

Lockheed now plans to start construction of a 51,000 sq. ft. laboratory, bringing to seven the number of buildings either completed or underway. It will also raise the Division's facilities to about 1,000,000 sq. ft. compared to some 96,000 sq. ft. it projected less than a year ago.

The new laboratory will supplement two similar research buildings occupied in September and a 14,000 sq. ft. experimental building soon due for completion.

Missile Systems Division payroll now numbers about 5,000 and Lockheed anticipates that sales in 1956 will more than double the $25 million recorded last year.

Ouest-Aviation Reveals Missile Projects

First details of guided missile activity by Ouest-Aviation (formerly SNCASE), including a series of strategic missiles with a completely new navigation system, have been disclosed by the nationalized French aircraft firm.

The company has developed another missile for armament on its Vautour bomber and is working on a long-range ground-to-air missile for which its *Trident* will serve as a manned prototype.

First pilotless *Trident* is expected to begin flight tests soon.

GE Sets Up New Missile, Ordnance Departments

General Electric Co.'s Defense Electronics Division has set up a Missile and Ordnance Systems Department under general manager George F. Metcalf with key elements to be situated in Pittsfield, Mass. and Philadelphia.

New department will take on systems responsibility for surface-basic weapon systems and associated equipment to be used on land and sea, according to Division manager, Dr. G. L. Haller.

Nucleus for the new organization will be GE's former Naval Ordnance Dept. in Pittsfield and its Special Defense Projects Dept. in Philadelphia. However, the company does not anticipate any substantial shift of personnel or facilities from present locations.

Five Firms Named In *Sidewinder* Program

Navy's announcement that *Sidewinder* air-to-air missile has entered operational status (see page 27) also made it official that five major firms are involved in its development and production.

In addition to prime production by Philco Government Industrial Division, Navy recently awarded a $1-million second source contract to General Electric Co. at Utica, N.Y.

Avion Division of American Car & Foundry at Paramus, N.J., built experimental missiles during the *Sidewinder's* research and development stage at Naval Ordnance Test Station, China Lake, Calif.

Two other firms named were Bulova Research and Development Laboratories, Woodside, N.Y., and Eastman Kodak Co., Rochester, N.Y. Participation by the latter confirms use of infra-red or heat-seeker type of guidance system. The company is also developing the Navy's *Dove* air-to-underwater missile believed to employ these guidance techniques.

Bell Sued on Computer Deal

Missouri Research Laboratories, Inc. has filed suit against Bell Aircraft Corp. for $12,267 in alleged unpaid overhead costs arising out of secret radar work it subcontracted from Bell in 1948 and 1949.

The St. Louis firm charged in Federal District Court, Buffalo, N.Y., that it incurred the expenses in modifying a radar computer under a $51,350 government sub-contract with Bell.

Marquardt Employment Up 65% Since January 1

Employment at Marquardt Aircraft Co., producer of the ramjet engines for the Boeing *Bomarc* missile, reached 2,000 on October 1—a 65% increase since the beginning of the year. Company expects it to reach 3,000 by mid-1957.

Distinction of being the 2,000th

employee went to George C. Johnson who joined Marquardt's test engineering division as an engineer.

Industry Briefs

SERVOMECHANISMS, Inc., specialists in aircraft and missile control systems, has opened new corporate offices at 445 Park Ave., New York City. Company also operates two divisions at Westbury, L.I., two in California at Hawthorne and El Segundo, a research laboratory near Santa Barbara, Calif., and has two Canadian subsidiaries at Toronto.

THE GARRETT CORP.'S AiResearch Manufacturing Division has begun construction of two new laboratory buildings in Los Angeles. New facilities will be used to broaden the company's electronic and instrument operations.

RAYTHEON Mfg. Co. of Waltham, Mass., has received a $60-million Navy contract to produce *Sparrow* III air-to-air missiles of undisclosed configuration.

HUGHES AIRCRAFT Co., Culver City, Calif., builder of the *Falcon* air-to-air missile, has received a $5,420,700 Air Force contract for fighter missile systems and support equipment.

FLIGHT RESEARCH, INC. of Richmond, Va., and Traid Corp. of Sherman Oaks, Calif., manufacturers of photographic recording instruments, have signed a joint sales representation agreement.

CONVAIR has awarded a $1-million contract to Berkeley Div. of Beckman Instruments, Inc. to develop and build an electronic synchronizing system to cross-correlate operational flight test data. It will be used in Convair's missile program presumably the *Atlas* ICBM.

NORTH AMERICAN AVIATION, Inc. will develop new titanium alloys of 170,000 psi tensile strength —40% higher than that of present alloys—under a $2.2-million Air Force contract.

OFFICE OF DEFENSE MOBILIZATION has awarded a rapid tax writeoff of $44,624 at 70% to Industrial Tool & Machine Co. of Smithfield, R.I., for manufacture of missile components.

Industry Highlights

By Fred S. Hunter

Few people realize the progress Lockheed's Missile Systems division has made in the last six or eight months. Truth is it has been little less than phenomenal. A year ago Lockheed's missile division had some good business, but it also could have done with some additional projects which could have produced a profit, not merely big, thick reports. Today, its contracts total 28 in number. Some of these, of course, are on the modest side in dollar-volume and future prospects. But others are highly stimulating contracts, leading all the way up to weapons system management.

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Because of the magnitude of three or four of these projects, Lockheed has already outgrown its expansion plans, which were pretty optimistic in the first place. Lockheed had every intention of being out of its Van Nuys missile facility by the end of this year. But it simply could not build its new plant at Sunnyvale fast enough. This left it no recourse, but to revise its plans so as to retain the Van Nuys facility, much to the disappointment of the California division, covetously eyeing the space. Here, incidentally, appears an ironic implication for the future. One of these days, when the manned aircraft passes out of the picture, it undoubtedly will be Lockheed's still growing missile division doing the coveting of the California division's Burbank space.

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Lockheed expects that one year from now it will have more than 10,000 employees on the missile division payroll. This not only assures the permanent continuation of the Van Nuys facility, but means more construction than originally planned probably will have to be added for the new facilities in the San Francisco Bay area, and with no waste of time.

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North American Aviation hasn't as yet appointed a chief engineer to succeed Ray Rice, who recently became general manager of the Los Angeles division. Most likely candidate probably is L. L. Waite, who now heads up the so-called MACE (Missile & Control Equipment) group at Downey. Waite was in engineering before he was upped to vice president at Downey, and it would be a logical promotion. MACE, as such, probably will be broken up after North American moves its corporate offices into the new general office building now under construction in El Segundo. This will leave the two divisional setups, Autonetics and Missile Development, at Downey.

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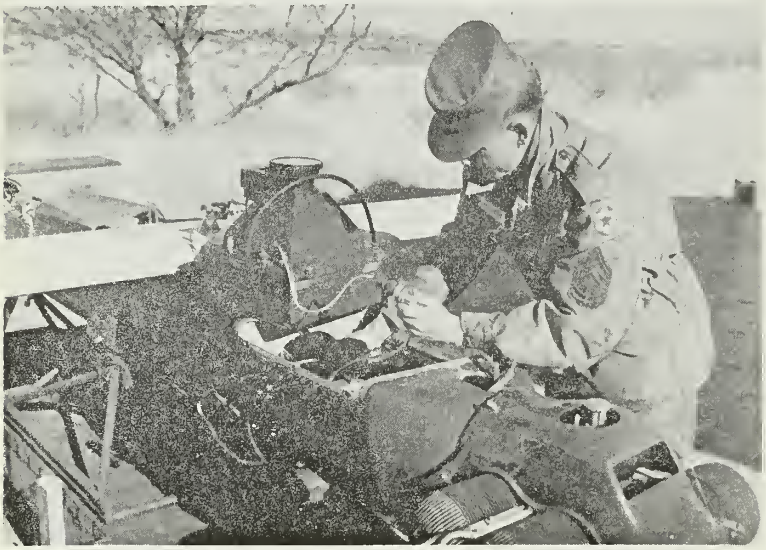
Convair is working hard to make Florida life more pleasant for its transplanted Californians. It has started construction on a $2,000,000 housing project at Cocoa Beach, Fla., where it will build 130 houses on a 45-acre site to lease to Astronautics employees working at the Air Force missile test center. J. R. Dempsey, program director for Convair's ATLAS intercontinental ballistic missile, said the employees will have the privilege of buying the homes through private financing.

NEW MISSILE PRODUCTS

MISSILE CAMERA



New 20-pound aerial reconnaissance camera designed by Hycon Mfg. Co. for use in missiles and high-speed drones features built-in image motion compensation for forward speed at the time an exposure is made.

The Hycon K-20 uses 9 x 9 film and a 6-in metrogen lens to provide maximum area of coverage. Initially, it was developed for the Radioplane RP-71 drone under direction of the Army Signal Corps Engineering Lab. Write: **Hycon Mfg. Co., Dept. M/R, 2961 E. Colorado, Pasadena, Calif.**

MINIATURE GYRO

Aeronautical Div. of Minneapolis-Honeywell Regulator Co. has developed a ½-pound, miniature integrating gyro company engineers feel may prove the answer to short-term inertial needs for a mass-production, low-drift-rate, floated gyro.

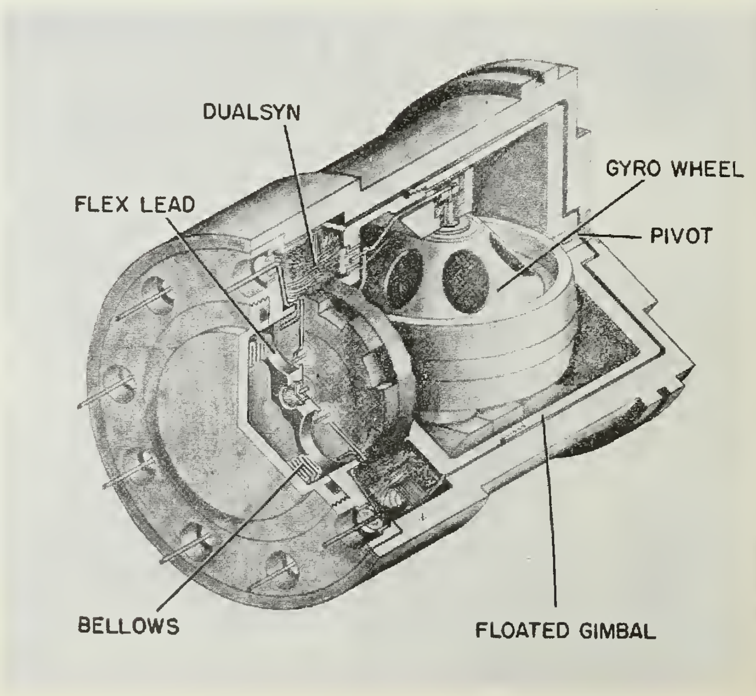
Called the MIG (miniature integrated gyro), it has entered production this month and low-quantity output is expected early in 1957.

M-H officials say the new unit has the same angular momentum as its HIG-5 gyro with performance comparable to the larger HIGs under rugged environmental conditions. The unit was developed for Douglas Aircraft Co. in its Navy instrument program, but its role was expanded for Jet Propulsion Laboratory's major missile program.

The MIG measures 1.75" in diameter and 2.5" long compared to 2.75" and 6" respectively for the HIG. One example of the extent of its miniaturization is a 7-watt internal heater element that is about the size of a dime.

M-H pilot production tests show a drift rate of less than .5 degrees/hour. Under trim with each warm-up, random drift rate will be in the order of .15 deg./hr., the company states.

Write: **Minneapolis-Honeywell Regulator Co., Aeronautical Div., Dept. M/R, 2600 Ridgway Rd., Minneapolis 13, Minn.**



STRUCTURAL ALLOY

A new magnesium-thorium alloy, designated HM21XA-T8, has been announced by The Dow Chemical Co for supersonic aircraft and missile applications. Quantities are on hand for immediate evaluation, the company states.

The new material is said to offer improved properties over its Dow predecessor, HK31A, in the 300 to 600°F range. It now extends that range to at least 700°, Dow officials say, and some tests have been conducted up to 900°. At 700°, the new alloy reportedly withstands prolonged exposure—in the order of 100 hrs.—with little effect on its properties.

Evaluation of HM21XA-T8 is being sponsored by USAF's Wright Air Development Center materials lab.

Write: **The Dow Chemical Co., Dept. M/R, Midland, Mich.**

FLURAN SEALANTS

Complete chemical resistance to highly oxidizing acids and alkalies, including red and white fuming nitric acid, is reported by Chemical Process Equipment Division of U.S. Stoneware Co. for its new fluorocarbon sealants.

Fluran J-20 and J-30 are designed for sealing stainless steel and aluminum joints in high-speed aircraft and missiles. Fluran J-20 is rated as moderately soft and J-30 as soft, and both may be applied from the container as received, or with a caulking gun having a 150 to 175°F heating chamber.

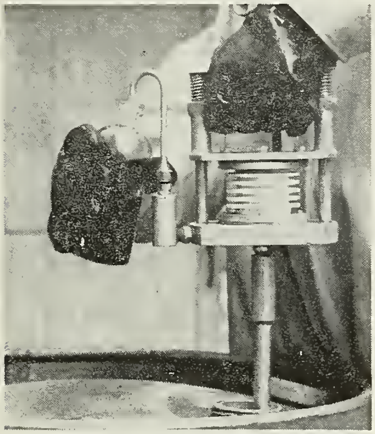
Fluran is a grey-white putty-like material and is said to have an

indefinite shelf life. Because of its high initial cost (now $55 per pound) manufacturer suggests its use only in highly critical applications. Write: **U. S. Stoneware Co., Dept. M/R, Akron 9, Ohio.**

ACID SAMPLER

A lightweight, hand-operated sampler developed for use by rocket and guided missile contractors in testing fuming nitric acid has been announced.

The unit is designed to permit rapid removal of acid samples from containers without the hazard of tilting or dipping. It is intended for use in field work or factory operations where nitric acid samples must be secured for laboratory analysis.



Operation of the unit involves placing the pick-up tube in a container and pumping a hand lever. The acid is transferred into a jar or receptacle near the handle. The device minimizes danger to the operator during the process, yet permits him to vary the position of the pick-up tube to insure that a representative sample is secured.

Unit weighs three pounds and is said to be priced at $274 each. Write: **Texas Metal and Manufacturing Co., Dept. M/R, 6114 Forest Park Rd., Dallas, Tex.**

VACUUM PRESSURE SWITCH

A Gorn GAB 1000 series of vacuum pressure switches respond to pressure as low as 2 inches of mercury absolute, and are said to retain their accuracy to ± 1 inch of mercury pressure under conditions encountered in missiles.

Operating element as a bellows that resists self-actuation under se-

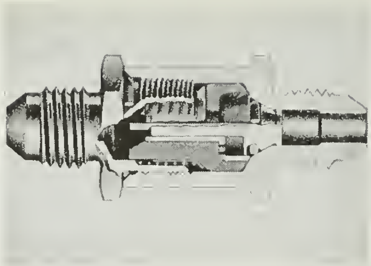
vere vibration to 2000 cps at 10 g. The switch was designed for use in inert gas vacuums. Write: **Gorn Aircraft Controls Co., division of Gorn Electric Co., Dept. M/R, 845 Main St., Stamford, Conn.**

CHECK VALVES

Protected type 3,000-psi stainless steel check valves for missile pneumatic systems guard the "O" ring seal on the valve poppet from damage due to flow turbulence or erosion.

This feature, the manufacturer says, allows a broad choice of synthetic materials for the seal since the tensile strength of the synthetic does not effect reliability of operation.

For example, a low tensile strength silicone can be supplied for



temperatures up to 450°F and special seals can be furnished for red fuming nitric acid.

The protected feature of the valve takes the shape of a cage with a cup-shaped end. When the valve opens, both poppet and seal move into the sheltered end and out of the flow stream around the cage. Literature available.

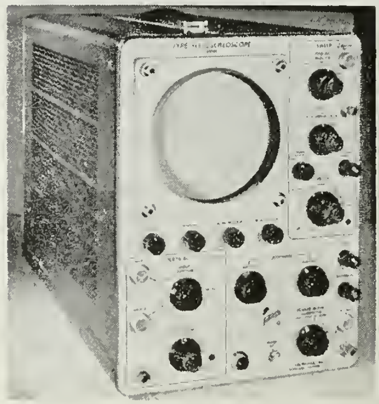
Write: **Mansfield & Green, Dept. M/R, 1051 Power Ave., Cleveland 14, Ohio.**

OSCILLOSCOPE

Tektronix has announced a Type 515 oscilloscope with a 5" cathode ray tube said to occupy less space and to have wider application than many larger instruments.

Size is 9¾" x 13½" x 21½". Bandpass is dc to 15 mc. with 0.023 μ/sec rise time. Calibrated sweeps from 0.2 μsec/cm to 2 sec/cm are said to be accurate within 3%.

The square wave calibrator has 11 steps from 0.05 v to 100 v said to be accurate within 3%. with a frequency of about 1 kc. Wgt. is 40 lbs.



Write: **Tektronix, Inc., Dept. M/R, P. O. Box 831, Portland, Ore.**

LOADING EQUIPMENT

Load-O-Matic, a new completely automatic loading platform for dock-to-truck materials handling operations has been introduced by Industrial Products Engineering Co. Hydraulically operated, it handles loads up to 20,000 pounds.

Up and down movement of Load-O-Matic is started by an automatic switch bar in the loading platform, or by an overhead pull switch if preferred. Platform is automatically stopped at the exact level of the truck floor by a leveling ramp which "bridges the gap" between platform and truck.

Load-O-Matic platform measures 8 ft. 6 in. by 4 ft. and is raised and lowered by a 8⅝-in. diameter piston. Lift speed is four seconds per foot.

Write: **Industrial Products Engineering Co., Dept. M/R, 26-40 Jackson Ave., Long Island City, N. Y.**

PROPELLANT VALVE

Hydromatics, Inc. has introduced a line of pressure-operated, multi-line propellant valves rated for use with a variety of fuels and oxidizers.

Valve design and materials are said to be suitable for controlling flow of liquid oxygen, JP-4, JP-5, air, helium, RFNA, WFNA, hydrazine, nitrogen, aniline, ethylene oxide, propyl nitrate, hydrogen peroxide, anhy-

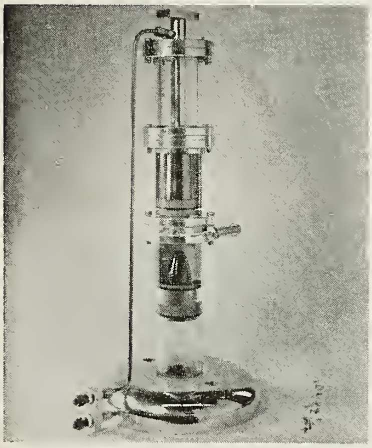
drous ammonia and water.

Light weight of the series is demonstrated by ½" — ⅝" 2-line model that weighs 2.5 lbs. Other types are available for 2-line or 3-line control functions for line sizes from ½ in. to 4 in.

The valves feature a floating ball-seat arrangement said to provide absolute zero leakage at extreme temperatures and pressures. Units are pressure actuated with inputs from 200 to 3,000 psi.

Line operating pressures handled by the valves range from zero to 1,500 psi. Write: **Hydromatics, Inc., Dept. M/R, Cedar Grove, N. J.**

SHOCK TESTER



A dynamic shock testing device, which measures only 26 in. high and 3 in. in diameter, yet produces a 12,000-pound thrust, is being marketed by Consolidated Electrodynamics Corp. under license with Convair.

The instrument is designed for shock testing of components for jet engines, aircraft, missiles and rockets.

The Hyge unit consists basically of a cylinder enclosed piston that is subjected to differential pressures on its two faces. There are only two moving parts—piston and a floating seal—with no complicated controls.

Design of the actuator is modular in concept to provide a variety of forms to meet specific applications. For testing large objects, a group of instruments can be connected and fired simultaneously to provide additional power and range. Literature

available. Write: **Consolidated Electrodynamics Corp., Rochester Div., Dept. M/R, 1775 Mt. Read Blvd., Rochester 3, N. Y.**

FREE GYRO

G. M. Giannini & Co. has developed a new free gyro, the Model 3416, with a drift rate said to be less than 18 minutes of arc per minute. It features a cast steel frame mounted solidly inside a structural outer shell having an integral cg mounting flange.

Shock specification for the Model 3416 is 50 g's in all axes. Potentiometers which supply outputs up to 70 volts for telemetering and control operations have a linearity of ±0.5% and resolution of 0.09°.

Motor is powered by 115, 200 or 26 volt three-phase 400 cps voltage.

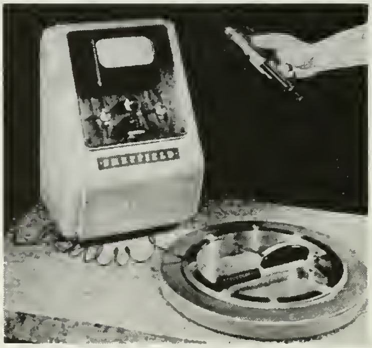
Write: **G. M. Giannini & Co., Dept. M/R, 918 E. Green St., Pasadena 1, Calif.**

INTERNAL DIMENSION GAUGE

Internal dimensions from 5 to 36 inches may be measured to an accuracy within several millionths of an inch by the Internal Calibrating Master. In kit form, the gauge has a plastic handle with a gauge cartridge mounted in one end and an adjustable screw assembly on the other.

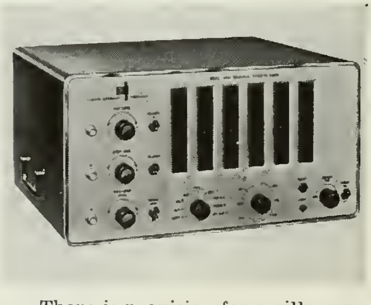
A series of ⅝ inch diameter bars of different lengths thread into the gauge handle to provide a wide range of adjustment. Connected to an electronic amplifier, various amplifications of the cartridge signal are available in different switching ranges.

Amplifications from 10 to 20,000 are available through switching. The gauge operates on 110 volt 60 cycle power. Write: **The Sheffield Corp., Dept. M/R, Dayton 1, Ohio.**



COUNTER TIMER

Model 226A universal counter timer has been designed for precise measurement of frequency, frequency ratio, period (1/frequency) and time interval. Featured are direct readout in kilocycles, megacycles, seconds or milliseconds with automatic decimal point indication.



There is provision for oscilloscope marker signals for trigger level adjustment of start and stop points. Three independent continuously adjustable trigger level controls permit full rated sensitivity at any voltage level between —300 and + 300 volts. Write: **Computer-Measurements Corp., Dept. M/R, 5528 Vineland Ave., North Hollywood, Calif.**

TEFLON HOSE & FITTINGS

Aeroquip Corp. has introduced a new combination of Teflon hose and "super gem" fittings for use in aircraft and missile fluid systems including red and white fuming nitric acid.

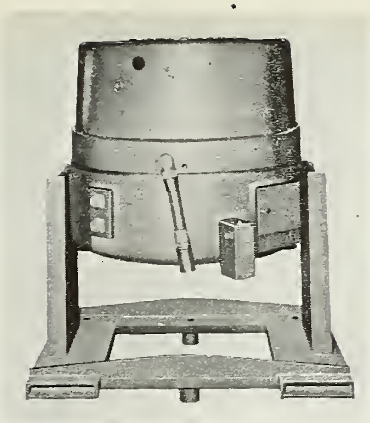
Aeroquip's Type 666 hose is rated for operation in temperatures from —100 to 500°F. The new 666000 fittings

features an arrangement wherein compression during assembly is applied to the wire braid only to grip the hose in the fitting. Fluid sealing and fitting retention become separate functions within the same fitting.

Reinforcement for the Teflon inner tube in the 666 hose is provided by stainless steel wire braid, making the assembly non-oxidizing inside and out. Fittings are reusable. Write: **Aeroquip Corp., Dept. M/R, Jackson, Mich.**

VIBRATION EXCITER

An oil-cooled, electrodynamic vibration exciter produced by MB Manufacturing Co. is rated to produce a continuous force output of 3,500 to 5,000 lbs. and equivalent acceleration in a frequency range from five to 2,000 cycles.



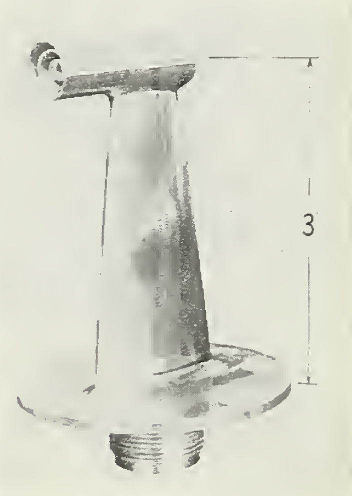
The Model C25HB meets these performance ratings at environmental chamber altitudes from 0 to 125,000 ft., relative humidities from 0 to 95% and temperatures between —100° and +300°F.

Exciter may be rotated 90° and operated in any position from vertical to horizontal. It is used with electronic or rotary power supply and either automatic or manual control system. Literature available.

Write: **MB Manufacturing Co., Dept. M/R, 1060 State St., New Haven, Conn.**

TEMPERATURE PROBE

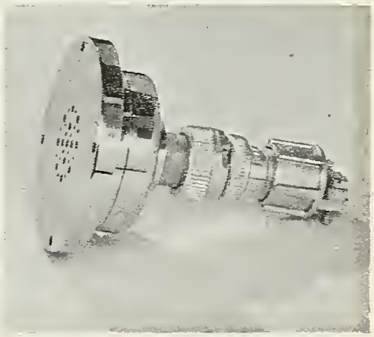
Rosemont Engineering Co. has introduced a total temperature probe designed to meet critical accuracy requirements of Air Force specifications for air measurement at speeds up to Mach 3 and higher.



Model 101U probe features a 50-ohm platinum resistance thermometer element that is said to be hermetically sealed without sacrificing the very low time constant.

Available literature describes probes that are useful to temperatures of 1500°C.

Write: **Rosemont Engineering Co., Dept. M/R, Rosemont, Calif.**



DYNAMIC PRESSURE PICKUP

A dynamic pressure pickup will measure pressures that may consist of complex waves from sonic vibrations, blast pressures and water ham-

mer in liquid-filled lines.

The Type 4-430 pickup features low internal impedance of 100,000 ohms, calibration retention, high output and lack of phase lag or overshoot between 3 and 2500 cps.

The pickup will operate at a pressure range of 10-4 to 100 psig and temperature range of —10 F to + 140 F. Size of the unit is 1⅞ in. diameter, and thickness of about 1 in. Write: **Consolidated Electrodynamics Corp., Dept. M/R, 300 North Sierra Madre Villa, Pasadena, Calif.**

ELECTRON MICROSCOPE

An electron microscope with better than 20 Angstrom resolving power operates at 100 kv and has a hinged objective lens for quick change or cleaning of pole inserts.

Also featured are a magnetic compensator, objective diaphragm with multiple apertures, and insert screen with binoculars for ultra-thin specimens. Pole pieces permit magnification to be continuously variable through a range of 5,000 to 100,000 diameters.

With diffraction pole pieces, the magnification ranges from 1,750 to 35,000 diameters. Camera equipment extends the range to 200,000.

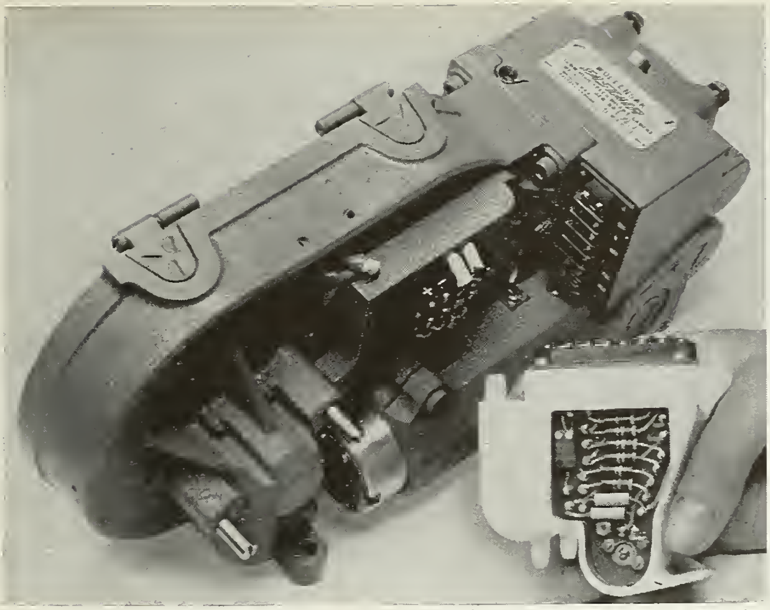
Weight of the unit is 1251 lbs. and it operates from 110 to 440 volt supplies. Cooling water of 2-3 quarts per minute at 30 psi or over is needed. Write: **North American Philips Co., Inc., Dept. M/R, 750 South Fulton Ave., Mount Vernon, N. Y.**

GUIDANCE MOUNTING

All external plumbing is eliminated in a new compact manifolded mounting base developed by Pacific Division, Bendix Aviation Corp. for a hydraulic missile guidance system.

The device was developed for Convair's Terrier missile. The package contains 18 components, all mounted on the manifold and interconnected with 15 ft. of integral plumbing. As a result, components can be removed readily for servicing and the entire system can be tested as a unit and installed in a minimum of time.

The Terrier's hydraulic system uses compressed air to deliver electrical power for the missile wing actuation through integral servo valves and cylinders, and hydraulic power for a remotely located roll actuator. Write: **Bendix Pacific Division, Dept. M/R, 11600 Sherman Way, No. Hollywood, Calif.**



TIMING GENERATOR

A new 2¼-ounce timing generator developed by Lockheed Aircraft Corp.'s Missile Systems Div. is designed to pulse at any rate from once to 3,000 times per second.

Intended to supply a time base on the film of airborne data recording cameras, the Lockheed-developed unit is said to be virtually G-immune. It is being produced under license by Electromation Co.

Initial application will be in GSAP cameras modified for data recording and in the newly developed Wollensak Fastair high-speed missile camera.

The new unit occupies 4 cu. in. of space. Write: **Electromation Co., Dept. M/R, 116 So. Hollywood Way, Burbank, Calif.**

FLOATED RATE GYRO

A floated rate gyro manufactured from Monel, Inconel and stainless steels has been developed that eliminates the need for heaters to counteract differential expansion effects on accuracy over a temperature range of —65°F to +165°F.

Type R-170 gyro is of the hysteresis synchronous type for operation from 26 or 115 volts at 400 cycles single phase or three phase. Input to the pickoff is 26 volts ac and output is 5 volts with a 10k ohm load. Gimbal restraint is achieved by means of a torsion bar. The rate ranges from 15° per sec. to 1000° per sec. with natural frequencies from 15 cps for low range units to 100 cps for high range. Accuracy is said to be better than 0.5% and sensitivity better than 0.1%.

Write: **Whittaker Gyro, division of Telecomputing Corp., Dept. M/R, 16217 Lindberg St., Van Nuys, Calif.**

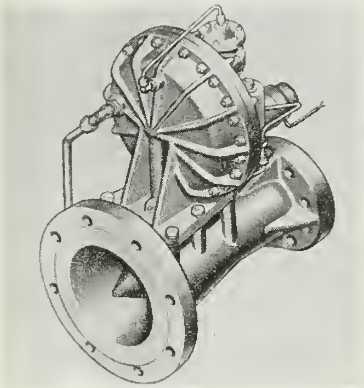
TELEMETRY TRANSMITTER

A VHF-FM telemetry transmitter is available that supplies 15 watts minimum rf power into a 50 ohm load over the frequency range of 215-235 mc. Type 1461-B is designed for PDM/FM modulation. The 1461-D is for FM/FM modulation. Either produces ±125 kc maximum deviation at the output frequency.

The transmitter is designed for bulkhead mounting. It uses an FM modulated crystal oscillator operating at 1/6 output frequency. Sine wave response from 100 cps to 80 kc is ± 2.5 db. Square wave response

has a rise and fall time of not more than 5 microseconds. Weight is about 34 ounces. Size of the unit is 5 19/32 x 3 13/16 x 4 inches.

Write: **Telechrome Mfg. Corp., Dept. M/R, 28 Ranick Drive, Amityville, N.Y.**



PNEUMATIC VALVE

A pneumatic pressure regulator and shut-off valve, developed by The Garrett Corp.'s AiResearch Industrial Division, is designed specifically for rocket, ramjet and jet engine facilities where source gases are stored under high pressure.

The new valve operates with a closing time of 1/10th of a second and provides a zero leakage shutoff control. Its regulating function is to reduce high pressure gas at 3,000 psi inlet pressure to a pre-determined lower outlet pressure.

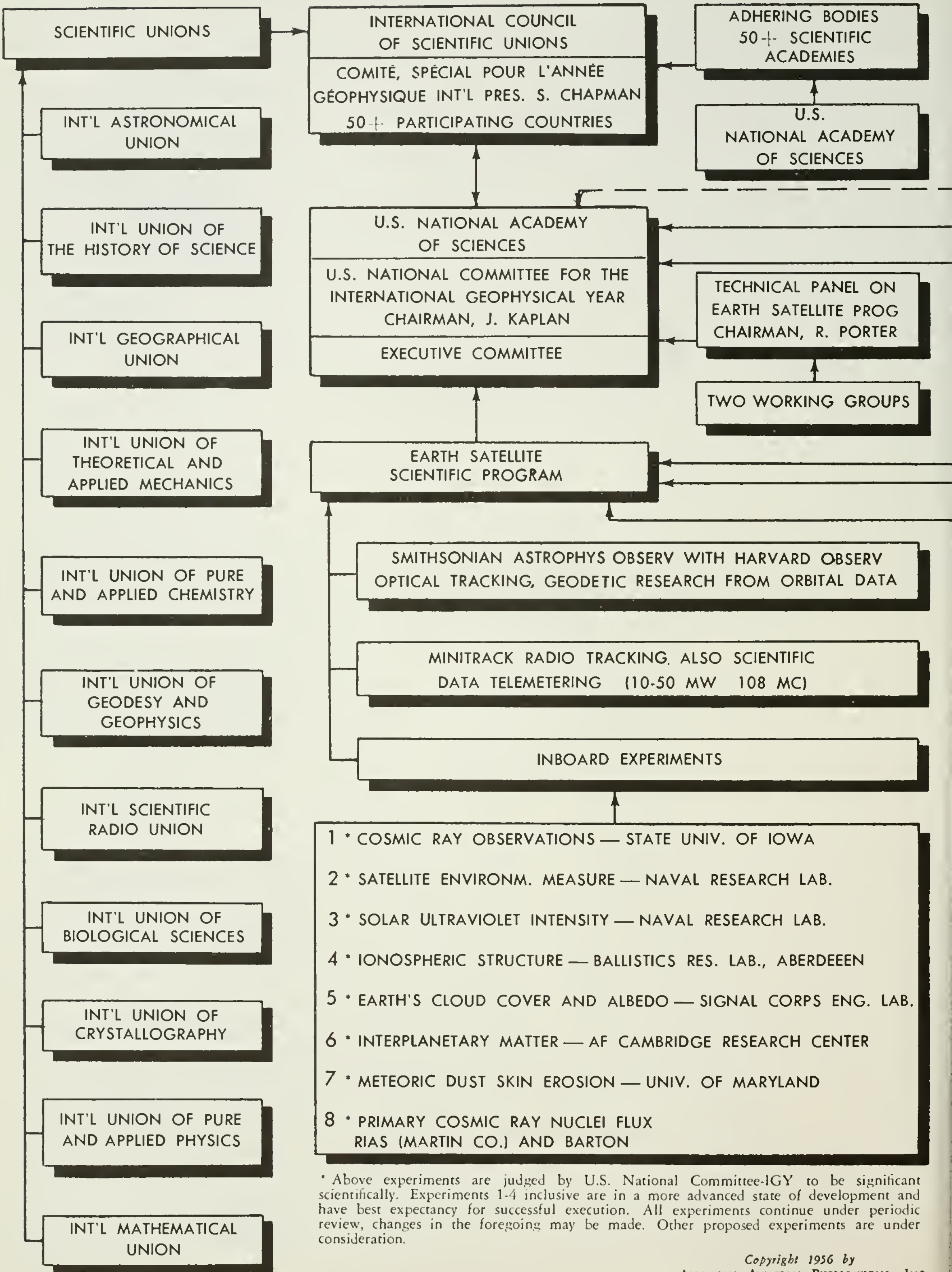
In addition, the basic valve can be used as a reducing and shut-off valve for other high-pressure industrial gas systems such as flowing nitrogen or natural gas. Write: **The Garrett Corp., AiResearch Industrial Div., Dept. M/R, 9851 Sepulveda Blvd., Los Angeles.**

Missile Literature

SCIENTIFIC SERVICES. New brochure outlines engineering facilities and services, including aeroelasticity and structural dynamics, aerodynamic research, aircraft operations, missile design, thermoelastic research, vibration analysis and testing. Write: **Allied Research Associates, Inc., Dept. M/R, 43 Leon St., Boston.**

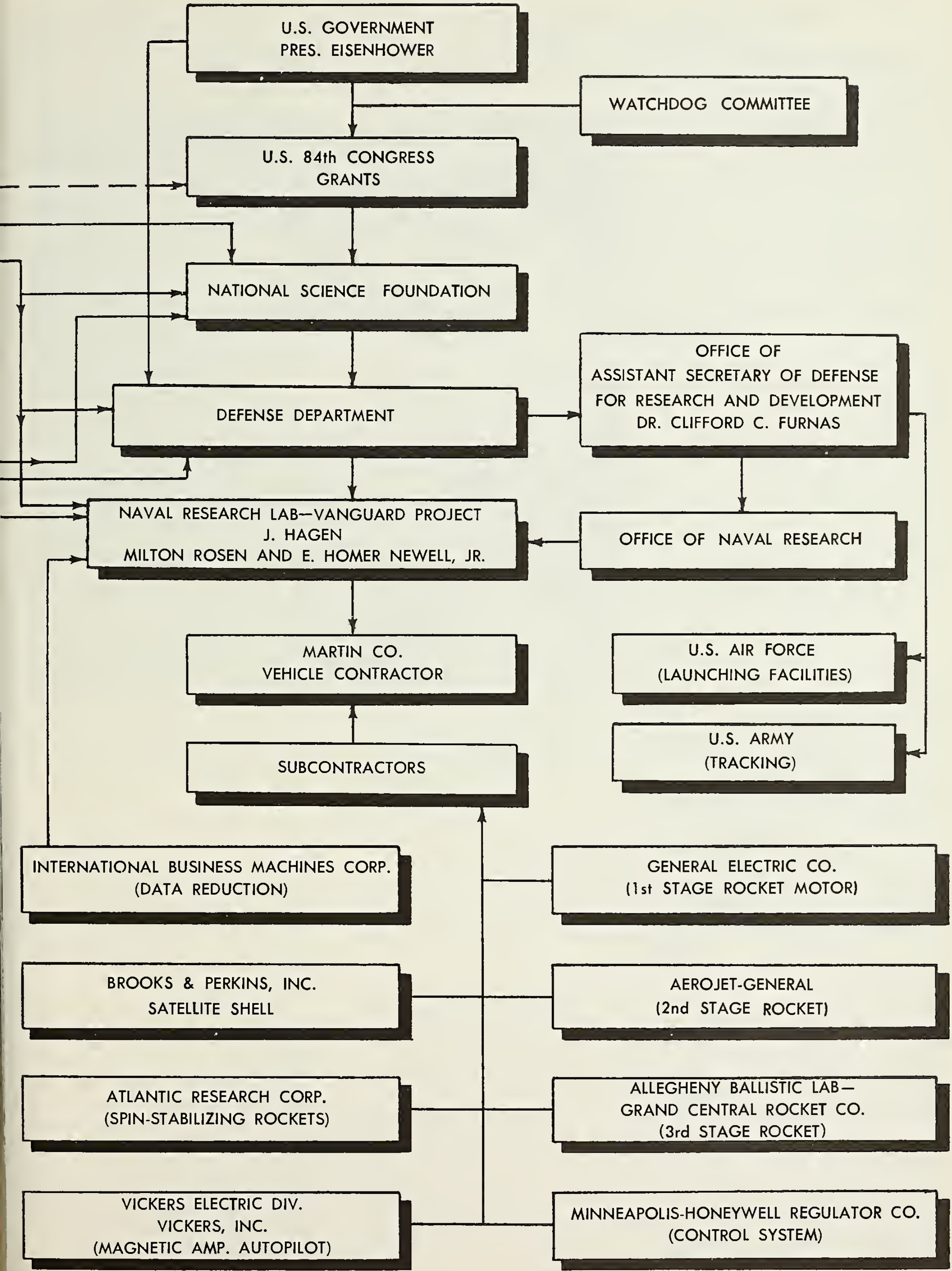
MISSILE FORUMS. Two new bulletins, GEZ-1741 and GEZ-1742, present extensive treatment of technical forums on guided missiles conducted by General Electric's special defense products department. Topics include systems engineering, aerophysics problems of hypersonic flight and hypersonic experimentation. Write: **General Electric Co., Apparatus Sales Div., Dept. M/R, Schenectady 5, N.Y.**

HYDRAULIC VALVES. Data sheets describe new 3-way selector and lightweight restrictor valves for 3,000 psi hydraulic service. Write: **Aircraft Products Co., Dept. M/R, 300 Church Rd., Bridgeport, Pa.**



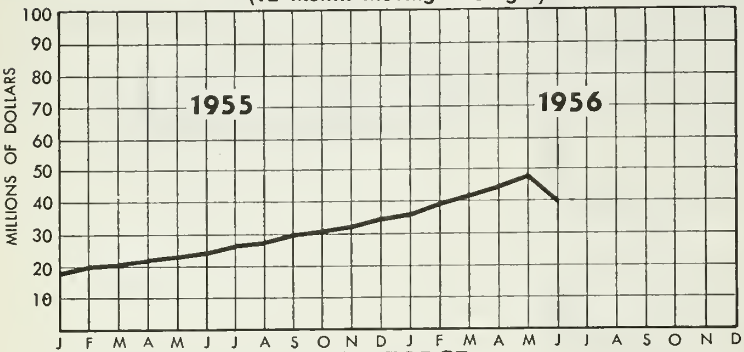
* Above experiments are judged by U.S. National Committee-IGY to be significant scientifically. Experiments 1-4 inclusive are in a more advanced state of development and have best expectancy for successful execution. All experiments continue under periodic review, changes in the foregoing may be made. Other proposed experiments are under consideration.

EARTH SATELLITE VEHICLE PROGRAM

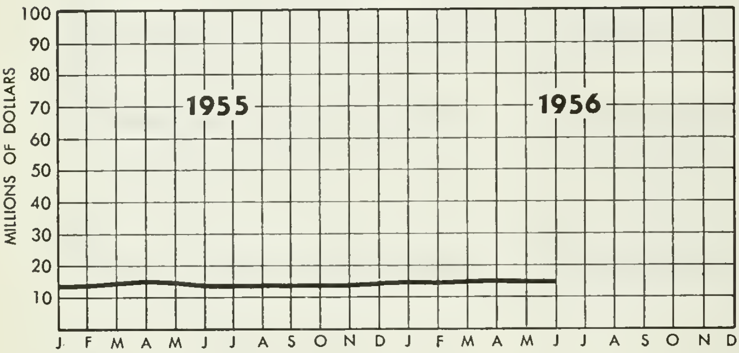


INDUSTRY BAROMETER

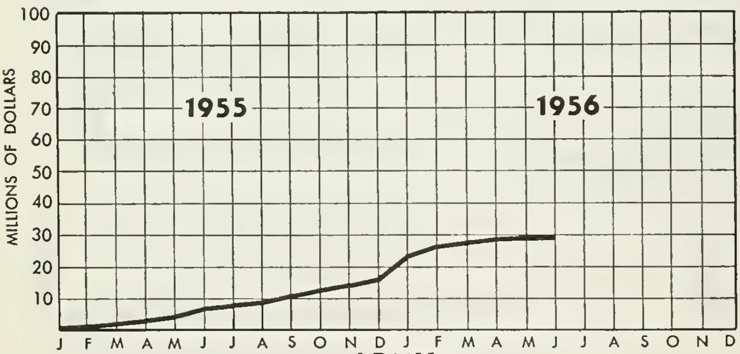
GUIDED MISSILE EXPENDITURES
(12 Month Moving Averages)



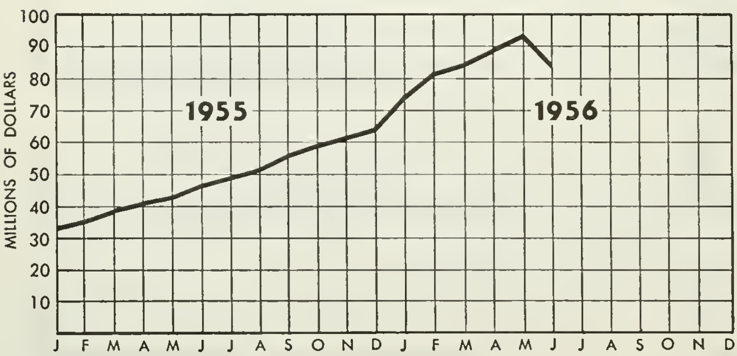
AIR FORCE



NAVY



ARMY



THREE SERVICES TOTAL

As missile expenditures by the three services change from month to month, these variations tend to observe some rather obvious trends. To eliminate the extreme peaks and valleys of the monthly data (see Industry Barometer-October 1956), we have employed a twelve month moving average. A twelve month moving average is a yearly average adjusted one month at a time.

For example, the expenditure figure shown for the Air Force for the month of January 1955 was obtained by adding the monthly figures of February through December 1954 and January 1955, then dividing by 12 to get the monthly average for this period.

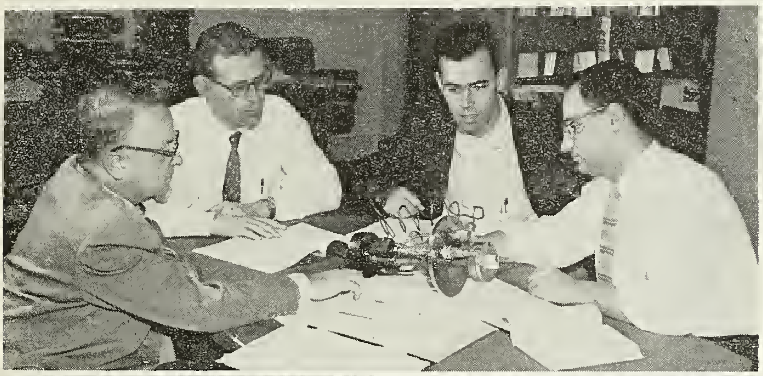
The accompanying graphs demonstrate rather forcibly the rapidity in which missiles have been integrated into the services as major offensive and defensive weapons. For the twelve month period ending January 1955, the average monthly guided missile expenditures by the Army was $302,000. Exactly one year later the average monthly expenditures was $24,151,000, an increase of $23,849,000, an increase of 7897%!

Navy's average monthly expenditures for missiles has been rather consistent. Low for the period January 1955-June 1956, was August 1955 ($13,886,000). High month was May 1956, $15,731,000, a difference of $1,845,000.

Air Force is currently spending some $45,000,000 per month on missiles and related equipment. This is an increase of approximately $25,000,000 over January 1955. As Air Force is obligating money for this account at the average rate of $60-65 millions per month, 1957 expenditures should reach the $60,000,000 per month level.

Missile expenditures by the Department of Defense have risen rapidly from $34 millions (January 1955) to the current level of $95,000,000 (May 1956). The services are now obligating money which will, in turn, show up as future expenditures. By the end of 1956 or early 1957, these obligations incurred will become expenditures boosting missile procurement well above the $100,000,000 per month level.

RIAS RESEARCH for Tomorrow



RIAS "gravity" researchers plan an experiment to aid in verification of some of the concepts of general relativity theory. Left to right are: Dr. Gerhart Groetzinger, Dr. Phillip Schwed, Dr. Albert Krall, and Dr. Louis Witten. Bottom: Dr. David Kahn, RIAS staff scientist, studies the change in surface resistivity of strained wires.

STAFFED by a select group of scientists who are encouraged to create their own programs of theoretical and experimental study, the areas under study at Martin's RIAS Baltimore laboratory are in no way tied to product development or production line problems of the parent company at Middle River, Md. Research contracts from outside agencies are acceptable, provided that they deal with basic research consistent with current interests of the RIAS.

Very few of the technological problems in any given field of endeavor can be solved—whether concerning missiles, rockets, spaceships, or any other scientific area. RIAS is not preoccupied with this consideration. Nevertheless, "the right piece of mosaic" turned up in a program of basic research may offer the essential clue to a whole chain of important technological developments.

Just as plants, with the assistance of moisture and fertilizer, can convert light and inorganic elements into food and fuel, so the reprocessing of material, plus the addition of energy which can be converted for human use, may hold a clue to the solution of resupplying energy for crew members for long expeditions on a satellite.

Although the practical design concepts for such a mechanism may still be far in the future, it is already too late to begin expanding our understanding of the fundamental energy transfers that take place in plants. Scientists at RIAS, therefore, are looking into the physical, chemical, and biological aspects of photosynthesis. These studies may turn up knowledge useful only in areas far removed from space flight. But that is the chance taken by any explorer who seeks new fields of discovery.

Another problem close to the missile and rocket designer is that of material. But while the difficult material environmental aspects of this problem are, and must con-

tinue to be the object of applied research, scientists also may find it profitable to devote attention to such phases as surface resistivity, lattice dislocations in both crystal and structure, or the effects of impurities on brittle fracture of tomorrow's materials.

These latter approaches are typical of the multitudinous problems being tackled by solid state physicists and metallurgical scientists at RIAS who seek new effects, or a better understanding of previously known phenomena, in order to be able to add to the store of knowledge of the properties of materials. Studies such as these may turn up clues to the eventual attainment of materials with strength properties on the order of magnitudes better than those which are presently available.

Welfare of Mankind

RIAS was chartered in 1955 to seek underlying knowledge of the phenomena of nature and to "evolve new technical concepts for the improvement and welfare of mankind." The function of the scientist at RIAS is to cultivate sufficient seeds of new knowledge, leaving to the practicing technician the function of harvesting the right crops.

A break-through in nuclear physics, for example, might, to the propulsion engineer, ultimately revolutionize his concepts of space travel, while to the medical researcher the same discovery might mean a new weapon in the war against cancer.

The process of transforming new discoveries into useful products, meanwhile, will be quickened by the relationship which RIAS enjoys with industry.

Through lectures and reports, members of the engineering profession, as well as representative groups of scientific colleagues from universities, government, and industry, are already being apprised of the developments in basic research occurring at the RIAS research center.

At present occupying temporary quarters at 2120 North Charles Street, RIAS will eventually move to a larger laboratory to be constructed in the suburban Baltimore area. END

CALENDAR

OCTOBER

29-31—Air Industries and Transport Assn. (Canada), annual general meeting, Chateau Frontenac, Quebec.

NOVEMBER

1-3—National Aviation Trades Association annual convention, St. Louis.

8-9—SAE national fuels and lubricants meeting, Mayo Hotel, Tulsa, Okla

13—Fourth Massachusetts Aviation Conference, Hotel Statler, Boston.

14-15—Aircraft Industries Association export conference, Miami Beach, Fla.

15-16—New England Radio-Electronics Meeting, sponsored by Boston and Connecticut section of IRE, Hotel Bradford, Boston.

25-30—American Rocket Society annual meeting, Henry Hudson Hotel, New York City.

28-30—First International Congress on Ozone, sponsored by Armour Research Foundation, Sheraton Hotel, Chicago.

DECEMBER

3—Flight Safety Foundation's 1956 seminar in cooperation with MATS, West Palm Beach, Fla.

6-7—Third Annual Meeting of American Astronautical Society, Edison Hotel, New York City.

17—Wright Memorial Dinner, Sheraton-Park Hotel, Washington, D. C.

JANUARY

14-15—Third National Symposium on Reliability and Quality Control in Electronics, sponsored by IRE, AIEE, RETMA and ASQC, Hotel Statler, Washington, D. C.

28-31—Eighth Annual Plant Maintenane Show, Public Auditorium, Cleveland.

30—Electronics in Aviation Day, sponsored by PGANE, IAS and RTCA, New York, N. Y.

FEBRUARY

26-28—Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles.

MARCH

7-9—National Conference on Aviation Education, sponsored by National Aviation Education Council, Mayflower Hotel, Washington, D. C.

People

Alexander Kartveli, vp and chief engineer of Republic Aviation Corp., under a change of duties program will devote full time to heading company-wide research

Alexander Kartveli

and development activities in aircraft, guided missiles, and programs in such fields as weapons systems, atomics, nucleonics, and electronics; **Richard G. Bowman** advances to chief engineer in charge of production and experimental en-

Dr. William O'Donnell

gineering; and **Dr. William O'Donnell** has been promoted to chief engineer in charge of aircraft and missile development.

Col. L. Zoeckler is the new chief of the aircraft and missiles division of Air Materiel Command. He will be responsible for procurement and production of all aircraft and guided missiles for the Air Force.

Dr. Herbert C. Corben is now a member of the staff of the Electronic Research Laboratory, The Ramo-Wooldridge Corp.

Dr. Bruno H. Wojcik has been appointed manager of research and development for the industrial chemicals division of the Olin Mathieson Chemical Corp.

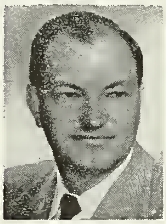
Dr. Raymond H. McFee, until recently director of research of the Electronics Corp. of America, has been appointed director of research for Aero-Jet General Corp's electronics and guidance division.

K. F. Umpleby was promoted from chief engineer to asst. Gen. Mgr. of the York division, Bendix Aviation Corp. W. H. Sims, Jr., has been named chief engineer.

Dr. Frank C. Hoyt has joined Lockheed's missile systems division as asst. director of research and head of the general and nuclear physics div. of the research labs.

Samuel Storchheim has been promoted to chief of manufacturing engineering & research in the Martin Co.'s nuclear division.

Charles D. W. Thornton was appointed director of research at Farnsworth Electronics Co.



Ballhaus

Thornton

Dr. William F. Ballhaus, chief engineer for Northrop Aircraft, Inc., Hawthorne, Calif., has been elected chairman of the Aircraft Industries Association's Guided Missile Committee for the coming year. He succeeds Edwin A. Speakman, vice pres. and gen. mgr. of Fairchild Guided Missiles Div.

Members of the AIA Guided Missile Committee, made up of representatives of the leading missile manufacturers in the country, have just returned from Norfolk, Va., where they were briefed on the operations and capabilities of the USS Boston, one of the Navy's new missile ships.

RAdm. William Henry Ashford, Jr. (USN, ret.) has been made manager of the newly formed missile applications division in the Electric Storage Battery Co.'s Exide industrial division.

Dr. Marshall N. Rosenbluth has joined the general atomic division of General Dynamics Corp.

F. E. Huggin, formerly of Lockheed missile system, has been appointed design specialist at the San Diego advanced electronic research and development center of Marvelco Electronics division, National Aircraft Corp.

Gerhard Reethof has been named chief of research under the

director of research and development for Vickers Inc.; **LeRoy D. Taylor** is asst. chief engineer for development.

George I. Willis, asst. to the gen. mgr. of Hamilton Standard, division of United Aircraft Corp., will head the company's new electronics department.

Peter J. Schenk has been named manager of the projects section for the new Technical Military Planning Operation in the General Electric defense electronics division.

William A. Rockwood has been made asst. gen. mgr. of the telecommunication division of Stromberg-Carlson, a division of General Dynamics Corp.; **Robert E. Dobbin** has been named chief engineer.

Kirke W. Marsh has been appointed general project manager on a major guided missile project of Bendix Aviation Corp., North Hollywood, Calif. Prior to joining Bendix in February of this year, he was senior project engineer for Fairchild Guided Missiles on a project for the Navy Bureau of Ordnance in cooperation with the National Bureau of Standards.

William Q. Nicholson, director of engineering for Hycon Manufacturing Co.'s instrument division, has been appointed chief staff engineer for the company. He will direct the development, introduction and promotion of new products. Before joining Hycon in 1951 Mr. Nicholson was a research engineer for Hughes Aircraft Co., and an electrical engineer at Gilfillan Brothers, Inc.

Arthur Sommer has been named mgr. of engineering for the American Bosch Arma Corp.'s Arma Division.

Donald R. Church has been named chief engineer of Acoustica Associates, Inc., a firm which designs and manufactures ultrasonic cleaning, processing and measuring systems. **Morris Kenny** has been appointed project engineer of the company's long-range Air Force missile systems development program; **Martin A. Damast**, senior electronic engineer.

J. Donald Haas, formerly a project engineer and then asst. Dayton representative of Reaction Motors, Inc., has been appointed asst. Washington representative.

Samuel Storcheim promoted to chief of mfg. engineering and research in The Martin Co.'s nuclear division.

RAdm. William Henry Ashford, Jr. (USN ret.), appointed mgr. of Electric Storage Battery Co.'s new missile applications division.

Marcus C. Eliason appointed gen. sales mgr. of Air Associates, Inc.

Charles D. W. Thornton appointed director of research at Farnsworth Electronics Co.

Donald M. Hazard has been promoted from assistant to the engineering mgr. of Pratt & Whitney Aircraft to chief of engineering operations at the company's Florida branch.

Karl D. Swartzel, former head of the physics dept. of the Cornell Aeronautical Laboratory, has been named chief research and development engineer of the Guided Missiles Div. of Republic Aviation Corp. He will be in charge of operations research as well as development of new missiles systems.

J. S. Morison has been appointed chief of Douglas Aircraft Co.'s missiles computing section and **O. E. Nemitz** chief of the Co.'s missiles data reduction section.

Baboo Ram Teree

Baboo Ram ("Bob") Teree, recently chief engineer of Weatherhead Co.'s Aircraft Division and Special Products Division, has been appointed chief engineer of Greer Hydraulics, Inc., Jamaica, N. Y.

Eugene E. Crowther has been named base mgr. of Lockheed Missile Systems Division's flight test base at Holloman AFB, Alamagordo, N. M., succeeding **Everett E. Christensen**, transferred to Van Nuys as asst. flight test division engineer. **Dr. Alan Andrews** has been appointed to the staff of the nuclear physics and engineering dept. and **Dr. William E. Frye** to the staff of the division's research laboratories at Palo Alto, Calif.

E. C. Cornford has been named head of the Guided Weapons Department of the British Supply Ministry.

The new Missile and Ordnance Systems Dept. of General Electric Co.'s Defense Electronics Division, with headquarters at Philadelphia, will be headed by **George F. Metcalf**, formerly gen. mgr. of the Special Defense Projects Dept.

John E. Lowe appointed director of personnel and pub. rel. of American Machine & Foundry Co.'s new guided missile launching system plant.

New Propellant Firm

Propellex Chemical Corp., a new firm specializing in development and production of propellants and explosives, has been formed by Dr. Robert A. Cooley, formerly of Olin Mathieson Chemical Corp.

Company has set up headquarters at 227 Oakley Place, East Alton, Ill. and has arranged for sufficient land, buildings and production facilities in that area. Plan is to place major emphasis in the aviation field on gas generating devices such as jet engine starters, aircraft and missile power units and non-electric safety devices.

In launching PCC, Dr. Cooley said company officials are convinced there is a whole new world of propellant and explosive actuated tools not only for the military but for industry.

As examples he cited guided transport missiles, auxiliary gas generators for emergency power, ejection devices and jet starters.

Dr. Cooley indicated that the library of propellants now known to industry permits the safe, reliable and economical use of propellant power to take the place of bulky air compressors or electric power sources. He noted, too, that more versatile and less expensive propellants based on fertilizer grade ammonium nitrate are rapidly being developed.

British Propellant Firm Formed

British Oxygen Research and Development Co., Ltd., a new firm, was formed early this month to take over the Research and Development Station of the British Oxygen Co. Group.

Firm has undertaken a twofold investigation of the basic problems of liquid oxygen, as a rocket propellant and for crew breathing needs.

Thompson to Build Fuel Test Facility

Thompson Products, Inc., Accessory Division has set 1957 as target for start of operation in a new $10-million facility to be built near Roanoke, Va. to test rocket and missile fuel and auxiliary power systems.

Propulsion Notes

By Alfred J. Zaehringer

Drastic reductions in solid propellant costs are in evidence with new Phillips Petroleum Co. propellant plant 66 at McGregor, Texas. The ammonium nitrate-carbon black-synthetic rubber propellant runs about ten cents per lb. sec. impulse which includes motor and propellant. Unit is the M15 RATO which has an operating temperature range of —75° to 170° F. One shot takeoff system for B-47 now costs about $160 a unit as compared to about double cost of old unit.

•

New process developed by Olin Mathieson is aimed at dropping costs of double-base solid propellants. Propellant cost for some newly developed units has dived below $1/lb. Previous double-base costs averaged $5-10/lb, especially for development units.

•

Scientists at Standard Oil Co. (Ind.), developers of new smokeless cartridge starter for B-57, believe solids will prove useful in space operations. Reason: about 30% greater performance than advanced liquid fuel motors and long-term storage under space conditions.

•

Rocket lab at Purdue is studying film cooling of rocket motors. Engineers at the lab conclude that experimental data are needed on friction co-efficients, flow of films, and turbulence of flows before film cooling can be put on a sound engineering basis. With WFNA and JP rocket motors using film cooling, loss in specific impulse varied linearly with film coolant flow. Loss of 1-4% in I_{sp} results with 2-9% coolant flow.

•

Is first firing of an atomic rocket motor near? AEC labs at Los Alamos and Livermore have openly announced research and development on nuclear rocket propulsion. Sandia Corp. also has been hinting at the same thing. General Electric has generally been pessimistic about an atomic rocket motor. However, it is significant to note that two of today's big guns in conventional rocket propulsion—North American and Aerojet—have entered the atomic side door in the reactor field.

•

Combustion work done at Royal Aircraft Establishment indicates that chlorine introduction may lower flame temperatures in hydrocarbon combustion. Carbon formation results in large heat absorption. Result: ramjets and turbojets that run cooler but emit black smoke exhaust. Bromine was also studied but it has a definite inhibiting effect on limits of flammability. British missile industry has put substantial emphasis on ramjets lately, although liquid rocket development is progressing satisfactorily.

THEORETICAL PERFORMANCE OF SEVERAL ROCKET PROPELLANT COMBINATIONS

Prepared by ROCKETDYNE *a Division of North American Aviation, Inc.*

SYMBOLS

- (light bar) Theoretical specific impulse (I_{sp}), sec
- (dark bar) Theoretical specific impulse x bulk density ($I_{sp}d$), (sec) $(\frac{g}{cc})$
- r Mixture ratio, lb oxidizer/lb fuel
- T_c Theoretical combustion temperature, F
- γ Ratio of specific heats, C_p/C_v
- M_c Average molecular weight of combustion products
- d Bulk density, g/cc, at 80F* of propellant combination at given mixture ratio.

$$d = \frac{r+1}{\frac{r}{d_{oxidizer}} + \frac{1}{d_{fuel}}}$$

*The density at the boiling point was used for those oxidizers or fuels which boil below 80F at one atmosphere pressure

CONDITIONS

Combustion chamber pressure = 500 psia

Nozzle exit pressure = 14.7 psia

Optimum nozzle expansion ratio $\left(\frac{\text{exit area}}{\text{throat area}}\right)$

Contraction ratio $\left(\frac{\text{chamber area}}{\text{throat area}}\right)$, assumed to be infinite

Adiabatic combustion

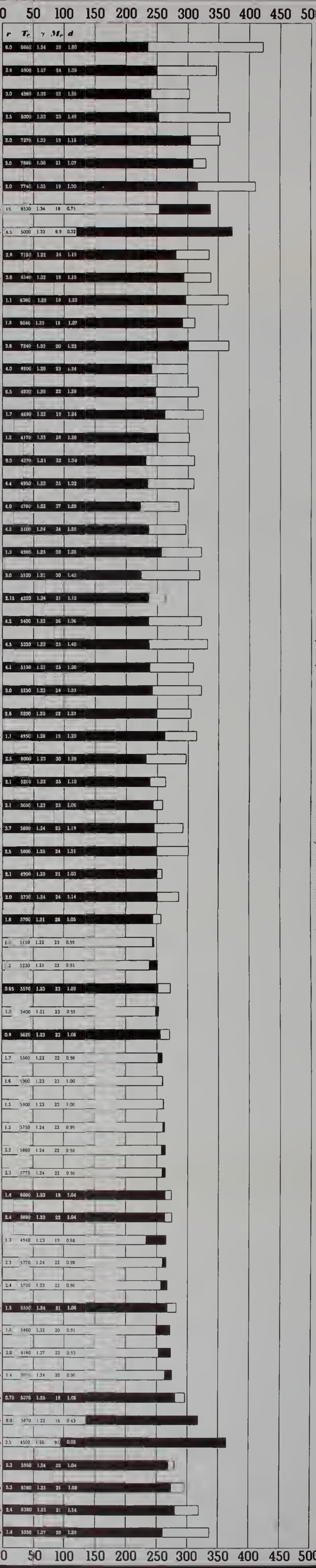
Isentropic expansion of ideal gas

Compositions expressed in weight percent

The composition of the combustion products was assumed to be frozen at chamber conditions. If shifting equilibrium were assumed during expansion, the theoretical specific impulse would be 3 to 10 percent higher. The most important parameter determining this increase is the combustion temperature, the increase being greater at higher temperatures.

TO CONVERT I_{sp} AND $I_{sp}d$ TO OTHER CHAMBER PRESSURES	
PRESSURE	MULTIPLY BY
200	0.89
300	0.94
400	0.98
500	1.00
600	1.02
700	1.03
800	1.05
900	1.06
1000	1.07
1100	1.09
1200	1.10

oxidizer	fuel	r	T_c	γ	M_c	d
BROMINE PENTAFLUORIDE	AMMONIA	6.0	6660	1.34	29	1.80
85% CHLORINE HEPTOXIDE + 15% NITROGEN TETROXIDE	TURPENTINE	2.8	5900	1.27	24	1.39
CHLORINE TRIFLUORIDE	AMMONIA	3.0	4980	1.32	22	1.35
	HYDRAZINE	2.5	6000	1.33	23	1.48
FLUORINE	AMMONIA	2.0	7270	1.33	19	1.15
	DIBORANE	3.0	7800	1.30	21	1.07
	HYDRAZINE	2.0	7740	1.33	19	1.30
	HYDROGEN (MAX. $I_{sp}d$)	19.	8530	1.34	18	0.75
	HYDROGEN (MAX. I_{sp})	4.5	5000	1.33	8.9	0.32
	JP-4	2.8	7100	1.22	24	1.19
30% FLUORINE + 70% NITROGEN TRIFLUORIDE	AMMONIA	3.8	6540	1.32	19	1.15
OXYGEN DIFLUORIDE	HYDRAZINE	1.1	6380	1.33	18	1.23
	AMMONIA	1.8	5046	1.33	18	1.07
	n-OCTANE	3.6	7240	1.33	20	1.22
99.6% HYDROGEN PEROXIDE	92.5% ETHYL ALCOHOL	4.0	4900	1.30	23	1.24
	JP-4	6.5	4830	1.30	22	1.28
	HYDRAZINE	1.7	4650	1.22	19	1.24
90% HYDROGEN PEROXIDE	HYDRAZINE	1.3	4170	1.25	18	1.20
54% HYDROGEN PEROXIDE + 40% AMMONIUM NITRATE + 6% WATER	KEROSENE	9.0	4270	1.21	22	1.34
100% NITRIC ACID	TURPENTINE	4.4	4950	1.23	25	1.32
95% NITRIC ACID	BUTYL MERCAPTAN	4.0	4780	1.22	27	1.28
RFNA (6.5% NO_2)	n-OCTANE	4.5	5100	1.24	24	1.35
RFNA (15% NO_2)	HYDRAZINE	1.3	4980	1.25	20	1.28
RFNA (22% NO_2)	TRIETHYL-TRITHIOPHOSPHITE	3.0	5520	1.31	30	1.42
	AMMONIA	2.15	4220	1.24	21	1.12
	TURPENTINE	4.3	5400	1.22	26	1.36
	POLYETHYLENE	4.5	5220	1.22	25	1.40
	JP-4	4.1	5150	1.23	25	1.30
	80% DIETHYLENETRIAMINE + 20% METHYLAMINE	3.0	5250	1.23	24	1.33
	UNSYMMETRICAL DIMETHYL HYDRAZINE	2.8	5200	1.23	22	1.23
NITROGEN TETROXIDE	HYDRAZINE	1.1	4950	1.26	19	1.20
ON 7030 (70% NITROGEN TETROXIDE + 30% NITRIC OXIDE)	TRIETHYL-TRITHIOPHOSPHITE	2.5	6000	1.23	30	1.28
	METHYL ALCOHOL	2.1	5210	1.22	25	1.10
	50% AMMONIA + 50% METHYL ALCOHOL	2.1	5050	1.23	23	1.06
	50% TRIETHYLAMINE + 50% ORTHOTOLUIDINE	3.7	5800	1.24	25	1.19
	TURPENTINE	2.5	5800	1.25	24	1.21
	AMMONIA	2.1	4900	1.23	21	1.03
	ETHYLENE OXIDE	2.0	5730	1.24	24	1.14
OXYGEN	ETHYL SILICATE	1.6	5700	1.21	26	1.05
	75% ETHYL ALCOHOL	[illegible]	5150	1.22	23	0.99
	METHYL ALCOHOL	[illegible]	5230	1.21	22	0.95
	NITROETHANE	0.65	5570	1.23	23	1.09
	92.5% ETHYL ALCOHOL	1.5	5400	1.21	23	0.98
	NITROPROPANE	0.8	5620	1.23	23	1.08
	ISOPROPYL ALCOHOL	1.7	5560	1.22	22	0.98
	PROPYLENE OXIDE	1.6	5900	1.23	23	1.00
	62.5% PROPYLENE OXIDE + 30.5% ETHYLENE OXIDE	1.5	5900	1.23	23	1.00
	ETHYLENE OXIDE	1.5	5750	1.24	22	0.99
	JP-4 ($^C/_H$ = 6.85)	2.2	5880	1.24	22	0.98
	JP-4 ($^C/_H$ = 6.00)	2.3	5770	1.24	22	0.98
	88% ETHYLENE DIAMINE	1.4	6000	1.23	19	1.04
	TURPENTINE	2.4	5880	1.23	22	1.04
	AMMONIA	1.3	4940	1.23	19	0.88
	METHYL CYCLOPENTANE	2.3	5770	1.24	22	0.98
	n-OCTANE	2.4	5790	1.23	22	0.96
	DIETHYLENETRIAMINE	1.5	5550	1.24	21	1.06
	METHYLAMINE	1.6	5460	1.22	20	0.91
	METHYL ACETYLENE	2.0	6180	1.27	22	0.93
	UNSYMMETRICAL DIMETHYL HYDRAZINE	1.4	[illegible]	1.24	20	0.96
	HYDRAZINE	0.75	5370	1.25	18	1.06
	HYDROGEN (MAX. $I_{sp}d$)	8.0	5870	1.22	16	0.43
	HYDROGEN (MAX. I_{sp})	3.5	4500	1.26	9.0	0.26
70% OXYGEN + 30% OZONE	JP-4	2.5	5950	1.24	22	1.04
30% OXYGEN + 70% OZONE	JP-4	2.5	6180	1.25	21	1.08
100% OZONE	JP-4	2.4	6380	1.25	21	1.14
TETRANITROMETHANE	HYDRAZINE	1.4	5250	1.27	20	1.28



Book Reviews

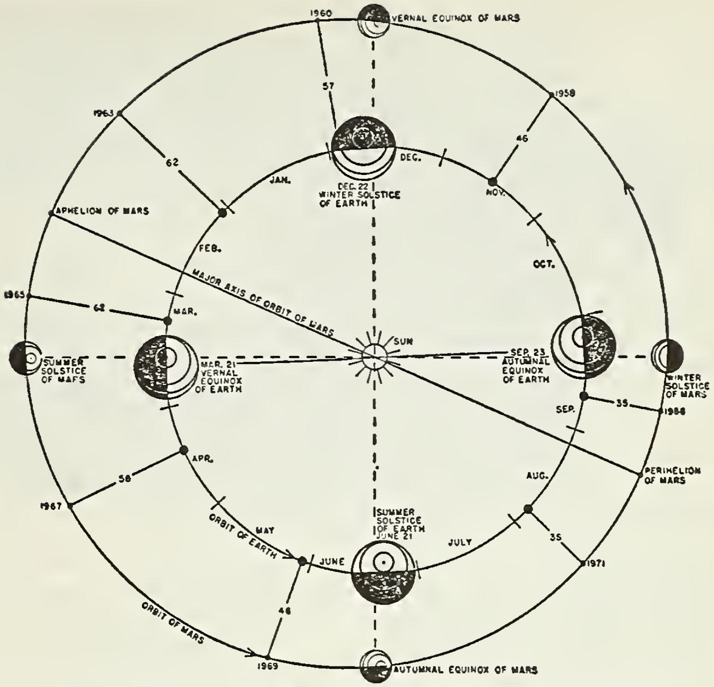


Illustration from GUIDE TO MARS. The orbits of the earth and Mars, as seen from the north pole of the sky, showing the near approach of the two planets. Notice that only those oppositions which occur in the fall are the close ones, when Mars is at perihelion.

AERODYNAMICS, PROPULSION, STRUCTURES. *By E. A. Bonney, M. J. Zucrow and C. W. Besser. Edited by Capt. Grayson Merrill, U.S. Navy. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 595 pp. $10.00.*

This second volume in a series on the principles of guided missile design contains a wealth of fundamental data for practicing missile engineers and students. Ten chapters are devoted to all aspects of missile aerodynamics from preliminary design to flight test, eight to missile propulsion including ramjet, turbojet and rocket power, and five to structures and design practice. J. S. M.

A SPACE TRAVELER'S GUIDE TO MARS. *By Dr. I. M. Levitt, 175 pp. $3.50, Henry Holt and Company, New York.*

The title of this book is rather misleading. The theme indicates the book is written for science fiction fans and that it departs from known facts. But Dr. Levitt actually presents a highly respectful and skillfully authored introduction to tomorrow's Mars trip.

First of all, however, as only the expert astronomer could do it, Dr. Levitt has introduced a guide to planet Mars and to some extent to other planets and the universe. One can rightfully say that the author has "distilled all that is known about Mars into a highly readable book of interest to everyone with a normal curiosity about the world around us."

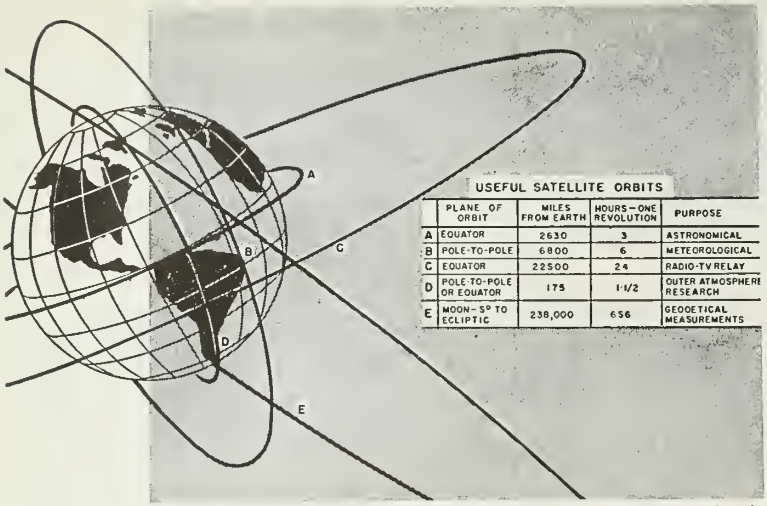
Furthermore, this is the kind of book that may merit consideration for vocational purposes. But this is not just another school book; this book belongs in the adult's library. Of particular interest is Dr. Levitt's concise and colorful description of the face of Mars and of atmospheric and climatic conditions on the neighbor planet.

In two appendices the author has included an absorbing section on the evolution of the solar system, its origin and the beginning of life. Illustrations are few but very good indeed.

E. B.

VISION, A Saga of the Sky, *By Harold Mansfield, 389 pp., $5.00. Duell, Sloan and Pierce, New York.*

In this book author Mansfield has presented the spirited history of Boeing Aircraft Company as it evolved from a spark of enthusiasm caught by William E. Boeing while witnessing America's first international aeronautical tournament at old Domiguez Ranch, a few miles south of Los Angeles, in January, 1910. The story of the early flying machines which inspired Boeing, the Curtiss, Bleriot, and Farman, is familiar to all whose life work is firmly entrenched in man's dreams of conquering the heavens. Though the



USEFUL SATELLITE ORBITS

	PLANE OF ORBIT	MILES FROM EARTH	HOURS—ONE REVOLUTION	PURPOSE
A	EQUATOR	2630	3	ASTRONOMICAL
B	POLE-TO-POLE	6800	6	METEOROLOGICAL
C	EQUATOR	22500	24	RADIO-TV RELAY
D	POLE-TO-POLE OR EQUATOR	175	1-1/2	OUTER ATMOSPHERE RESEARCH
E	MOON—5° TO ECLIPTIC	238,000	656	GEODETICAL MEASUREMENTS

Illustration from SATELLITE! shows useful orbits for different kinds of satellites contemplated during the next few years.

names and events belong to the history of Boeing Aircraft Company, the story is that of all aviation industry and mankind with the dreams, ambitions, set backs, and goals which have characterized the development of present day aviation. It is a book which, if begun, must be read; it is a book truly dedicated to, and inspiring, vision.

W.R.

SATELLITE! *By Erik Bergaust and William Beller, 287 pp. $3.95, Hanover House, New York.*

Erik Bergaust and William Beller have accomplished a difficult feat. They have written a book which is technically accurate and at the same time immensely fascinating. There are not many popular books which contain as an appendix a list of technical references and very few scientific books which are so absorbingly written you hate to put them down.

The authors have taken full advantage of their close contacts with the planners of the U.S. satellite program. They have dwelt on the background and the early history of the project and have presented the latest up-to-date technical information on the first satellites, their scientific applications, as well as on the technical problems of rockets, control and telemetering.

But there are other topics besides instrumented artificial satellites. Starting with a discussion of present rocket research planes, such as the X-1 and X-2, the book leads to their logical extension, the piloted satelloid vehicle which circles the earth in a satellite orbit partially supported by aerodynamic lift.

Beyond this the authors approach more cautiously such controversial topics as the giant space stations and exotic schemes of propulsion, such as photon rockets and gravity control; but all of it makes fascinating reading. The book ends with a discussion of a crucial problem, educating and training personnel for the age of space.

S. Fred Singer

How About a *DEGREE* In Missile Engineering?

By Captain Grayson Merrill, USN

NO first-line university, to the writer's best knowledge, offers open courses leading to a degree in Guided Missile Engineering.

Policy-making executives of leading United States institutions of learning should establish courses of instruction in Guided Missile Engineering, ultimately to achieve the present stature of Aeronautical Engineering. Available textbooks, students and teachers make this practical. Great public interest and essentiality to our national defense make it desirable.

The greatest proportion of U.S. engineers are working on research and development financed by the Department of Defense and, if the Fiscal Year 1957 budget is a guide, over one-half of these will be working on guided missiles.

It is paradoxical, therefore, that these engineers must train themselves "on-the-job" rather than in the nation's universities.

One probable reason for the tardiness of universities to set up guided missile instruction is the important factor of what unclassified literature they can utilize in teaching the subject. The Department of Defense has assumed no responsibility for creating such a body of literature and that which exists is principally in the form of uncorrelated technical papers sponsored by the technical journals.

Technologies employed in Guided Missile Engineering are probably more diverse than in any other field of application. There should be a broad undergraduate base, including mathematics through the calculus, physics, chemistry, electronics, mechanical engineering, and sufficient of the humanities to ensure social responsibility and administrative, as well as technical capacity.

Proper instruction using appropriate textbooks could lead to a BS or MS degree. A doctorate probably would involve specialization in one of the missile components, such as guidance, propulsion, aerodynamics, and would, of course, require original work of significance.

Effective guided missile instruction could be given by instructors presently working in allied fields, such as aeronautical, mechanical, and ordnance engineering. However, it obviously would be advantageous to recruit engineers, scientists, and technical officers of the Armed Services who can provide the desirable ingredient of practical experience.

In view of the great demand for such persons in the industry and the latter's salary advantage over institutions of learning, it is expected that retired persons will be a best source of experienced teachers, at least for some time.

Public opinion, in the form of literature and entertainment, indicates there is a deep-seated interest in guided missiles for young people. They see in it a fascinating challenge and a lucrative career which operates now to preserve national security and in the future to enable the exploration of space. A survey of any undergraduate technical body probably would show a strong predilection to guided missile careers.

Government will be forced to establish a positive program to solve the problem, possibly in the form of subsidy or other incentive for students of technologies important to national defense.

Patently, any university which already has established courses in Guided Missile Engineering will be in a position to benefit from such a program and serve its country at the same time.

Spare Time Rocketeers

A new section has been established by the Rocket Research Institute in Sacramento, California, to make a contribution to the International Geophysical Year: The designing, construction, and launching of an Intermediate Altitude Sounding Rocket to be known as *Spark* I.

Spark I system actually consists of two rockets, a 350-lb thrust, 85-second duration, liquid oxygen-alcohol sustainer rocket and a 5,000-lb thrust, one-second duration, solid-propellant booster rocket. Calculations indicate that the liquid sustainer will be able to carry instruments to altitudes in excess of 100,000 feet.

The Institute's project is being carried out by five development groups, Airframe, Facilities, Liquid Propulsion System, Projects, and Solid Propulsion System. The activities of each group are directed by professionals in the field. Consequently, even though the educational program is a non-military, unclassified endeavor, its value is increased because participants are guided by personnel with substantial industrial rocket experience.

The Rocket Research Institute, a non-professional organization with headquarters in Glendale, California, was established in 1943. All work is of a basic unclassified nature and members gain experience through "spare-time" training programs in which actual solid and liquid propellant rockets are designed, constructed, and tested.

Participation in the *Spark* I training program is open to all and a desire to learn more about rocket propulsion is the only prerequisite. Dues are $10 per year. For additional information, contact RBI Membership Committee, 2901 Rubicon Way, Sacramento 21, California.

18 Million Manhours Without Accident

A safety milestone unprecedented in the aircraft industry is claimed by Convair. Announcement that 88 consecutive days worked without a lost-time accident recently was given at Convairs' San Diego plant as a reminder to its 35,000 employees of their own unparalleled safety achievement. The 18,000,000 accident-free manhour mark reached was double the record-setting 9,000,000 manhours worked at Convair-San Diego last year without a lost-time accident.

For the 1955 achievement, the National Safety Council recognized Convair-San Diego as having established a world record for safety in the aircraft industry. Meanwhile, an inter-plant safety rivalry was developing rapidly as Convair-Pomona, the guided missile production facility Convair operates for the U. S. Bureau of Ordnance at Pomona, Calif., approached a full year worked without a lost-time accident.

Approximate man-hours worked without a disabling injury at Convair-Pomona recently was 9,821,224 established over a 359-day work pe-

riod. Convair-Pomona attained the one-year no-acciden mark Oct. 25, with a manhour total of nearly 10,-000,000. Pomona's lower manhour record is attributable to its smaller payroll—less than one seventh the number at Convair-San Diego.

Redstone's Housing Crisis Being Eased

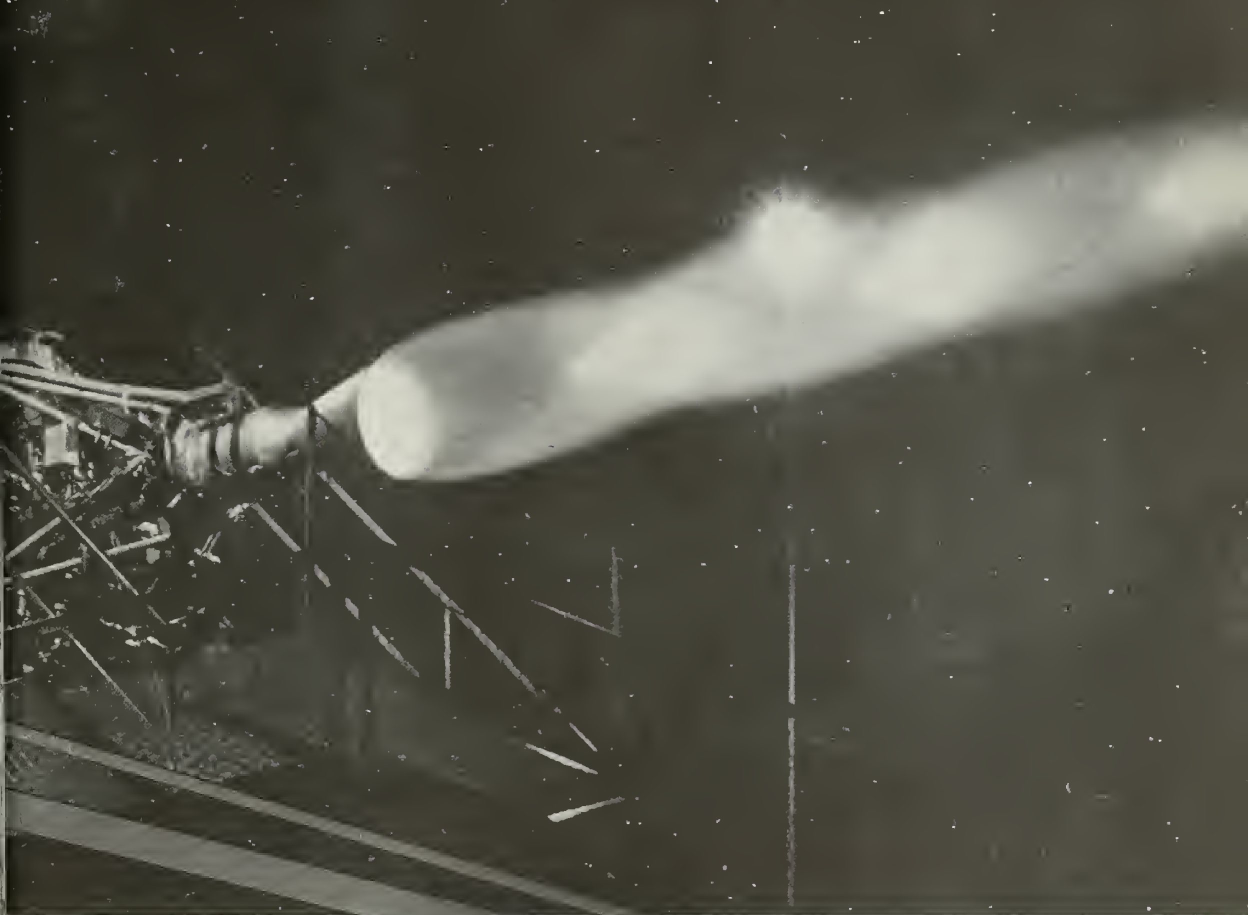
Critical housing shortages at the Army Ballistic Missile Agency and the Redstone Arsenal near Huntsville, Ala., are being relieved with award of a contract for immediate construction of 270 Capehart-type apartment dwelling units. These are the first of 670 such units already authorized.

Bush Construction Co. of Norfolk, Va., was awarded a $3,789,000 contract for the first 270 units. A contract of $98,502 for off-site utilities to serve the units was awarded to Nichols Plumbing & Heating Co. of Birmingham, Ala. Work has begun after ceremonies in which a charge of missile explosive replaced the traditional spade to break ground.

Contract specifications for the additional 400 units are being drawn for circulation to prospective contractors. Redstone already has 125 Wherry-type units. More than 9,000 civilians and 2,000 military personnel are employed at the missile and rocket center.

In another step to ease the housing shortage, special certificates of eligibility for housing benefits under Title 809 of the National Housing Act have been authorized for 500 essential civilian workers. Almost 300 of the certificates had been issued within the first week of the authorization which enables the Federal Housing Administration to guarantee more mortgages in given areas and to provide for lower down payments than on normal FHA-guaranteed mortgages.

m/r DECEMBER, 1956



missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

In This Issue:

USAF MISSILE ROUND-UP • RESEARCH AND DEVELOPMENT

missiles and rockets

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editorial

How USAF Can Aid and Benefit Too

THROUGHOUT THE ALMOST FIVE DECADES of military aeronautical development, civil aviation has been a great and positive beneficiary.

Will the civil sciences (including civil aviation) benefit in like measure from the military development of missiles and rockets?

This is a very logical question. There are many skeptics unable to foresee much real gain for the civil world in the necessarily hush-hush weapons projects now under tight military control. Up to now, at least, the military services have hardly been in a position to use an open road approach for cooperating with the civil sciences.

But the answer to the question of benefit is resoundingly in the affirmative. And there is at least one positive indication that the military services are fully cognizant of the need for cooperation.

Meteorologists, astrophysicists, geologists and others have been aware of the tremendous potentialities that guided missiles embrace as research tools for their respective fields. Up to now much of valuable scientific information obtained from upper air rocket research has been closely held by the military.

But now comes the USAF's Air Research and Development Command with a heartening attitude. Lieutenant General Thomas S. Power, ARDC's Commander, told the Aviators Post of the American Legion in New York last month that there must be better cooperation between civilian and military in joint scientific ventures and that such cooperation will benefit both. He gave every indication of recognizing and understanding the grave problem of scientist and engineer shortage. He stressed, too, the importance of giving scientists freedom in their work.

This forward-looking attitude is being translated into action. The test phases of the advanced USAF missile projects, such as the ICBM programs, are understood to be considered for joint scientific-military advantage. Since USAF needs to test its big missiles under almost true space flight conditions, it realizes that such tests will yield incalculably valuable information to many sciences.

The cooperation between the military and scientists in the space flight program is well known. The extension of this cooperation into the field of missiles and rockets holds great significance, for ICBM's in true space flight conditions should harvest a vast amount of scientific data.

We salute ARDC and General Power for this new look of cooperation and suggest that this joint effort can lead to even greater scientific progress. Many top missile scientists have discussed the feasibility of using ICBM hardware for scientific research flights to the moon and for circumlunar flights. In its search for the "ultimate" weapon in ballistic missiles, the USAF may find unlimited avenues to success by greater use of scientists from many fields in its weapons program.

WAYNE W. PARRISH.

missiles and rockets **vol. 1 no. 3**

features

news & trends

rocket engineering

industry spotlight

next issue

January m/r will feature Navy Missile Power and Navy Astronautics. Also: Buyer's Guide to the Electronics Industry.

cover picture:

M/R's cover shows test bed firing of a 50,000 lb. North American/Rocketdyne oxygen-alcohol engine for Cook Research Laboratories' Mach 2 test sled. Perfect diamond shock patterns depicted here will become an increasingly common sight to American missileers as vehicles like NAA's intercontinental Navaho reach full operational development. See Henry T. Simmon's feature article, page 77.

columns

departments

photo credits:

Harry Compton, E. Hull, pp. 24, 25, 26; GE, p. 32; Avco, p. 33; U.S. Air Force, pp. 55, 57, 58, 59, 60, 61, 62; Douglas, p. 65; NAA, pp. 77, 78; m/r, pp. 82, 83, 84; Aerojet, pp. 90, 91, 131; Westinghouse, pp. 99, 101; South African Interplanetary Society, p. 102; Exide, pp. 106, 112.

when and where

NOVEMBER

Nov. 28-30—First International Congress on Ozone, sponsored by Armour Research Foundation, Sheraton Hotel, Chicago.

DECEMBER

Dec. 3—Flight Safety Foundation's 1956 seminar in cooperation with MATS, West Palm Beach, Fla.

Dec. 5-7—Instrumentation Conference sponsored by IRE Professional Group on Instrumentation, Atlantic Section, Atlanta Biltmore Hotel, Atlanta, Ga.

Dec. 6-7—Third Annual Meeting of American Astronautical Society, Edison Hotel, New York City.

Dec. 10-12—Eastern Joint Computer Conference sponsored by IRE, AIEE, ACM, Hotel New Yorker, New York City.

Dec. 17—Wright Memorial Dinner, Sheraton-Park Hotel, Washington D. C.

JANUARY

Jan. 14-15—Third National Symposium on Reliability and Quality Control in Electronics, sponsored by IRE, AIEE, RETMA and ASQC, Hotel Statler, Washington, D. C.

Jan. 28-31—Eighth Annual Plant Maintenance Show, Public Auditorium, Cleveland.

Jan. 28-Feb. 1—Institute of the Aeronautical Sciences 25th annual meeting, Sheraton Astor Hotel, New York City.

Jan. 30—Electronics in Aviation Day, sponsored by PGANE, IAS and RTCA, New York, N. Y.

FEBRUARY

Feb. 14-15—Air Force Assn. Annual Jet Age Conference, Sheraton Park Hotel, Washington, D. C.

Feb. 26-28—Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles.

MARCH

March 7-9—National Conference on Aviation Education, sponsored by National Aviation Education Council, Mayflower Hotel, Washington D. C.

March 25-27—American Society of Tool Engineers, Silver Anniversary annual meeting, Shamrock Hilton Hotel, Houston, Texas.

book reviews

AIRCRAFT MATERIALS AND PROCESSES. *By George F. Titterton, 5th edition. Published by Pitman Publishing Corp., 2 West 45th St., New York. 398 pp., illustrated.*

An up-to-date treatment of latest processes, materials and specifications used in the aircraft industry, authored by the Asst. Chief Engineer of Grumman Aircraft Engineering Corp. Includes emphasis on new materials such as titanium, plastics, superstrength steels. J. S. M.

OPERATIONS RESEARCH, ARMAMENT, LAUNCHING, *By Grayson Merrill, Harold Goldberg, Robert H. Helmholtz, Third of a series of six edited by Capt. Grayson Merrill, U.S. Navy. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 508 pp. $10.00*

This third volume of this ambitious series sets out to tell guided missile designers, engineers, instructors, graduate students and everyone connected with modern aerial warfare something about the strategy and tactics of missile warfare; why they're needed; what kind of warheads for what kind of targets; the operational conditions under which they will be stored, transported and used.

The book was apparently written on the very valid assumption that even the most technically concerned will be better able to make the best judgment if he knows something of the why and how of a project's ultimate use.

It is not, however, a book for the layman or political science student. It treats its subjects—operations research, armament and launching—with scientific accuracy and thoroughness. But for all its thoroughness, it is still broad in scope as a listing of some of the chapter headings will indicate. The first, National Procedure, covers the basic responsibilities in the missile field of the armed services and of the contractor, including sections on Government laboratories, educational institutions, etc. Chapter three is called Determination of an Operational Requirement, covering weapons effectiveness, target damage definitions, weapons shortcomings, etc. Additionally there are chapters on tactical doctrine, mathematics of operations research, armament research and development, target vulnerability, warheads; fuzing requirements, safety requirements and arming components, evaluation and testing; elements of launching and design principles.

Operations Research shows how armed services requirements derive from legal roles and missions and outlines the teamwork in the missile industry needed to meet these requirements. The Armament section describes how to design a missile warhead and fuze to destroy its target. The Launching section treats the

booster assemblies, catapults, and airborne and surface launchers that are used. The vocational potentialities of the book are rather obvious.

For those who intend to develop, manufacture or use guided missiles this third volume should prove a valuable library addition. S. H.

RADIO TELEMETRY. *By Dr. Lawrence L. Rauch and Myron H. Nichols, 461 pp, 2nd Edition, $12.00. John Wiley & Sons, Inc., New York.*

At last a book on this subject is available. For the first time material previously scattered in reports and papers is brought together. Although a 2nd edition, the first was a limited printing for the Air Force. Methods, foundations and techniques are given together with appendices. For anyone doing telemetry research and development the book is a "must". Rauch's position among the "firsts" in this field as a telemetering scientist is well known. His and Nichols' experience is well attested in the completeness of the material both in technical and practical matters covered.

PROPERTIES OF COMBUSTION GASES. *Prepared by Aircraft Gas Turbine Development Dept., General Electric Co. Published by McGraw-Hill Book Co., Inc. Two volumes. $75.*

A set of comprehensive combustion gas thermodynamic tables, compiled for the first time, with the aid of an International Business Machines Co. electronic computer, that is expected to prove of considerable value to those engaged in combustion research, in development of gas turbines and turbojet engines and in aircraft and missile propulsion studies.

FLUID DYNAMICS OF JETS. *By Shih-I Pai. Published by D. Van Nostrand Co., Inc., Princeton, N. J., 228 pp. Price, $5.50.*

A comprehensive treatment of the subject by an associate research professor of the University of Maryland's Institute of Fluid Dynamics and Applied Mathematics, this book was designed to meet the needs of engineers, research workers and students.

letters

British Not So Far Ahead

To the editor:

. . . In your November issue, page 50, under the heading "British Move Ahead," you make the following statement about the rocket grenade experiment for upper-atmosphere temperatures and winds:

"This is not a new technique, having been previously used by a U.S. Naval Research Laboratory . ."

Actually, the experiments have been carried out previously at the White Sands Proving Ground by the Signal Corps, U.S. Army.

It might be of interest to your readers that the all-weather rocket-grenade experiment will be carried out during the IGY at Fort Churchill, Manitoba, Canada, as a joint Signal Corps-University of Michigan venture. A pre-IGY firing, Aerobee SM 1.01 was successfully carried out on November 12, 1956 . . .

Dr. Joseph Otterman
High Altitude Engineering Lab.
Dept. of Aeronautical Engineering
University of Michigan
Ann Arbor, Michigan

Satellite vs. Earth Rotation

To the editor:

. . . MISSILES & ROCKETS, Vol. 1, No. 1, p. 78, says: "*Vanguard* will be launched at an angle of 35 to 45 degrees to the equator in a southeasterly direction. During each orbit of the satellite the earth will have moved about 1600 miles to the east if the orbit requires an hour and a half." Page 18 of the National Academy of Science's booklet INTERNATIONAL GEOPHYSICAL YEAR states that the satellite is to be sent into a southeasterly orbit at 18,000 mph and at an altitude of 300 miles above the Florida coast; it will make one revolution every 1½ hours, each time appearing about 25° further to the west of the launching site, due to the eastward motion of the earth beneath it. These calculations appear to be in error through failure to consider that the satellite, into whatever orbit it may be accelerated, will still retain the eastward motion it possessed while resting on the surface of the earth, so that the entire orbit will revolve almost in synchronism with the rotation of the earth.

It is fallacious to state that the "earth will rotate beneath the satellite" while the satellite is making an orbit, as if the satellite had been captured after approaching from outer space. As acceleration is imparted to the satellite at the launching site it will have only one relative motion; it will return (at the surface) to the original position after completing an orbit, regardless of any motion of this point in space, since the satellite also has this inherent motion.

It is apparent that any simple acceleration in any direction can only determine the angle of the satellite orbit with the equator, but will not prevent the satellite from returning to the same point, or the rotation of the orbital plane with the rotation of the earth. The orbit will be distorted by the Coriolis effect but this effect is equal and opposite in the two hemispheres, cancels and may be disregarded in relation to this problem.

The eastward motion of the surface of the earth crossing the earth-sun line at Cape Carnaveral (N. Lat. 28°30′) will be about 923 mph. The satellite will be in orbit at an altitude of approximately 300 miles, however, at which heighth the circumference of the earth would be an additional 1,917 miles, requiring an easterly motion of 993 miles per hour to maintain the position of the orbit with respect to the rotating earth surface at the launching site. Since no special east-west accelerations are to be provided, the satellite will fall behind, but only 120 miles further west of the launching site with each revolution of 1½ hours, approximately 2° of longitude, not the anticipated 25°.

This means that the satellite would return approximately overhead again only after some 180 revolutions, or 270 hours (11¼ days), rather than the expected 14-15 revolutions (21-22 hours). It will appear only some 120 miles to the west of Cape Carnaveral after completing the first revolution, 240 miles after the second, etc., giving the observers

of the western U.S., Asia and South America excellent opportunities for observation, but possibly not surviving long enough to be seen over the eastern U.S.

As startling as these considerations are concerning the success of proposed observations, it appears that they are soundly based and an immediate review of plans are in order . . .

Yours truly,
Charles C. Littell, Jr.
Engineering Associates
Dayton 9, Ohio

The U.S. Office of Naval Research which has cognizance over VANGUARD launching, states that the earth's velocity has been taken into account in the original launching and orbiting calculations. It is a vector in the total. NRL says further that once the satellite is in an orbit, it is a separate entity, and the earth can rotate under it just as it does under its larger satellite, the moon.

ed.

Radiation Pressure

To the editor:

. . . In reading the articles on space flight and the earth satellite program, I wonder if any scientist has considered the effect of the sun's light on the satellite or the space vehicle. When I took physics in high school, we had an instrument in the classroom which reacted very readily to light projected against it. I have forgotten its name, but you will recognize it from my description.

Two pieces of aluminum foil were mounted at 90° to each other upon a bearing to form a crossed vane assembly which because of the bearing were free to revolve. Alternate sides of the vanes were painted black.

As the assembly revolved in the beam of light, the shiny side of one vane was always exposed to the light and was repelled by the light rays causing the vane assembly to revolve very rapidly. This entire assembly was enclosed in a glass bell from which the air had been removed.

If such an action takes place under comparatively weak light in a partial vacuum, what will the result be when extremely strong sunlight strikes the surface of a light shiny object such as your satellite in perfect vacuum of outer space?

You will recall another effect indicating the strong pressure of sun-

light in the action of the luminous particles and gas making up the tail of a comet as it approaches the sun and swinging around it heads out into space again. The tail of the comet is always *away* from the sun as if a strong wind from the sun were blowing it, even when the speed of these particles in the tail must exceed that of the comet itself to place the tail always *ahead* of the comet as it rushes away from the sun in its return to outer space.

I'm not a scientist and I lack the "know-how" to calculate the pressure of sunlight on a surface of any given size, but as a very interested layman in the conquering of space I can't help wondering from my high school science whether this idea has been considered.

Perhaps if the pressure is sufficient why not utilize it, like a ship when sailing at sea in a strong wind, to propel a space vehicle once it had neither atmosphere nor gravity to retard it.

Norman F. Blubaugh
7148 W. 93rd Place
Los Angeles 45, California

Reprints Wanted

To the editor:

. . . I very much enjoyed reading the first issue of your magazine. It is timely and fulfills a real need in the field.

Particularly, I enjoyed the article entitled "Teamwork: Key to Success in Guided Missiles," by Dr. Wernher von Braun.

If reprints of this article are available I would greatly appreciate it if you would send me six copies . . .

Joseph M. Cahn
Guided Missile Research Division
The Ramo-Wooldridge Corporation
8820 Bellanca Avenue
Los Angeles 45, California

To the editor:

. . . The performance chart concerning liquid propellants and oxidizers included in your November, 1956 issue of MISSILES & ROCKETS, after page 134, can be very useful to me. I would appreciate a reprint of the chart if one is available . . .

L. H. Sachs, Attorney
Legal Department
General Electric Company
Building 100
Evendale, Ohio

To the editor:

. . . The article, "Teamwork: Key to Success in Guided Missiles" by Dr. von Braun in the October 1956 issue of M&R, expresses most succinctly the attitudes here at Douglas regarding the development of guided missiles. We would like to give each of our engineers a copy of this article and therefore wish to know whether reprints of it are available.

E. P. Wheaton
Chief Missile Engineer
Douglas Aircraft Company, Inc.
Santa Monica Division

Missile Production Is Challenge

To the editor:

. . . Congratulations on the test flight and number 2 of MISSILES & ROCKETS. They are excellent prototypes for what is destined to be the leading publication in man's last frontier.

We who are actively engaged in this field have awaited just such a magazine; the context and format of M&R are perfect.

The writer hopes that future issues will carry some articles on the production aspects of the business, as well as the interesting engineering side. The actual production analysis, tooling and material handling problems which production engineers must surmount to produce these new vehicles are challenging. The new avenues explored and techniques developed for the fabrication and assembly in metals which were laboratory specimens a short time ago are every bit as fascinating as the aerodynamics and propulsion problems which daily confront the designer. Tooling up for miniaturized cybernetics can be as interesting and challenging as the original design for the systems.

This production engineering is what gave America her technological advantage over the rest of the world. It is hoped that, within the limits of Security, (there goes that word again) some of these facets can be explored in your pages . . .

Chris Lembesis, P.E.
Unit Leader, Material Handling and Plant Layout
Missile Development Division
North American Aviation, Inc.
Downey, Calif.

Wilson Shocks Nation's Rocket Experts

Defense Secretary Directive Confounds Missile Men at American Rocket Society Annual Meeting

By Erik Bergaust and Seabrook Hull

NEW YORK—The timing of Defense Secretary Wilson's "roles and missions" directive cutting the heart out of the Army's guided missile effort was uncanny enough almost to have been intentional. The edict fell and exploded like one of their own devices, wreaking shock and confusion among some 1600 top U.S. rocketeers and missileers gathering in New York City for the Eleventh Annual Meeting of the American Rocket Society.

Though Wilson's latest missile order (see page 70) was meticulously avoided as a subject for discussion on the Society's formal agenda, it topped all others as a topic of talk and perplexed-to-heated comment in hotel hallways, rooms and hospitality suites.

The general consensus among the men who design, engineer and produce America's super-weapons ranged from a puzzled "Hmmm . . ." to "It just doesn't make sense . . . a life or death decision for the country . . . the easy way out in settling an interservice squabble . . ."

In other ways, the ARS annual meeting was the most successful yet. To the industry, it was certainly newsworthy and profitable. Papers presented ranged from such titles as: *Theory and Experiment on the Burning Mechanism of Composite Solid Propellants, Molybdenum for High Strength at High Temperatures,* and *British Sounding Rockets to: Lifetime of Artificial Satellites of the Earth, Some Social Implications of Space Travel,* and *Projecting the Law of the Sea into the Law of Space.*

More than ever before, there was a sense of "having arrived." Missiles and rockets were fast becoming the most important U.S. defense industry. Space flight already was in the serious planning stage. The general public's knowing smile of tolerant superiority had changed to a look of serious respect for a vital, deadly business.

As outgoing ARS President Noah Davis handed over the keys of office to incoming President Commander Robert C. Truax, the society found itself in the best condition in its history. It was financially solvent with "comfortable" reserves. Membership was increasing at a rate of 200 a month with an "over 6,500" year-end membership virtually assured.

Plans were approved for doing even more to enable the ARS journal, *Jet Propulsion,* to serve its membership better. New committees were set up in the areas of solid propellant rockets, liquid propellant rockets, ramjet propellant and combustion, instrumentation and guidance and space flight. Commander Truax predicted that these committees would "sink their roots deep among the

1957 ARS President Truax
. . . *Calm mind for crucial job*

Rocket Society's A. C. Slade
ARS finances in good shape

IRBM man Lovell Lawrence
"I could teach in Carolina . . ."

membership and play a major part in fostering the technical life of the society." Two new board members, Convair's Krafft Ehricke and Lt. Col. John P. Stapp, were elected to replace retiring members John B. Cowen and George P. Sutton.

Wilson Brings Consternation

The shock and surprise at Wilson's order limiting Army missile operations to firings of 200 miles or under stemmed not from theories and convictions over the military roles and missions of the three services. It came from deep concern, even alarm, at the possible ultimate effects of this decision on America's race with Russia to maintain technological superiority in the air.

The most oft-heard question was "What does this mean to Redstone Arsenal's Intermediate Range Ballistic Missile project?" The most advanced of all the ballistic missile programs, it looked at first glance as though when money appropriated for research in 1957 had run out, that would be it. Why should the Army fight for research funds to build a missile it could never use? And what would happen to the top research and development team, a ballistics missile team, built up under rocket pioneer Wernher von Braun?

In line with the Army's newly assigned sole cognizance over short range surface-to-air missiles would they be ordered to adapt ballistics know-how to anti-aircraft missiles? Bell Telephone and Douglas Aircraft wondered too—would their anti-aircraft *(Nike)* missile experts suddenly be asked to go ballistic? And Chrysler Corporation wanted to know: "Do we stop making *Redstone* missiles or will our contract be shifted over to the Air Force?

Wilson's directive may have cleared some confusion in the Pentagon, but what everyone is wondering now is if it didn't create a great deal more on the outside where many think it counts more—in the industry.

And there was bitterness too. "What ballistic missile does the Air Force have?" was one question. "Of course, the Air Force has *some* missiles, but what are they? Of their air breathing missiles the *Matador* is inadequate and obsolescent. The *Snark* is a subsonic missile which is already obsolescent, although it is not even ready."

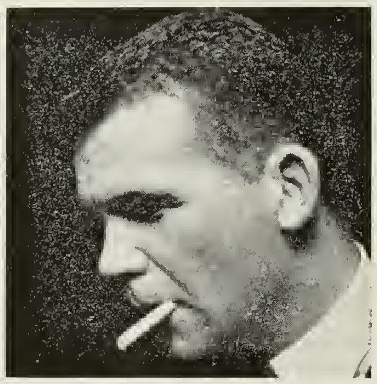
". . . the *Nike* can shoot down a *Navaho* . . . four USAF fighters and a bomber, the B-58 Hustler, are faster than the *Snark* . . . After fooling around for 12 years with air breathers; only after much resistance, AF finally conceded there might be something to ballistics missiles after all . . . Army already has much experience . . . in the joint Jet Propulsion Laboratory-Army project a *Jupiter* device was fired more than 3,000 miles . . . 95% of U.S. ballistics know-how is in the Army."

These were but a few of the comments that flew fast and heavy against the decision during the week-long ARS session. Some points might have been stretched a bit in the enthusiasm and deep-seated feelings of the speakers. However, they express the views and feelings of men who form the very heart of our missile effort. They are the brains, the inspired and dedicated men, the pioneers with the imagination and technological abilities to probe the unknown. They are the brains without which this country cannot win the battle of technology it now wages with Communist Russia. And the fact that these brains are now troubled

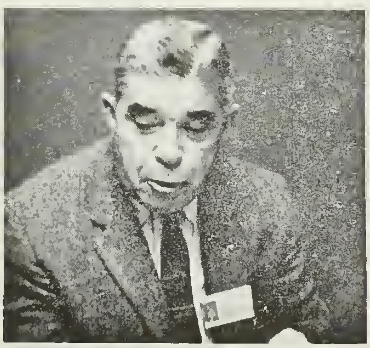
ARS Personalities

Wernher von Braun
. . . *People stood up and applauded*

Edwards AFB's Gompertz
. . . *Keep testing until they work*



GE's Fred Brown
. . . *Rocket engine sales up*



Aerojet's George Pelletier
. . . *No change in ICBM contracts*

Convair's Krafft Ehricke
. . . *New ARS director*

Boeing's Norman Baker
. . . *Will the AF keep Bomarc?*

COOPER DEVELOPMENT'S WASP ROCKET displayed at Coliseum power show.

may be the most serious result of the new roles and missions directive.

In this connection MISSILES & ROCKETS obtained the following statement from Major General J. B. Maderis, Commanding General, Army Ballistic Missile Agency, Huntsville, Ala.:

"The Department of Army has authorized me to announce that any existing developmental missile program will not be affected by any forthcoming decision in service operational responsibilities. The Secretary of Defense has repeatedly stated that a decision with reference to roles and missions would not involve the termination of any particular weapon system."

There was a notable lack of comment in support of the Defense Secretary's decision. Though there were AF representatives attending the meeting, most were notable for their silence. Those who did comment backing up Wilson's views, did so without enthusiasm, apparently without conviction. And many of those who claimed agreement obviously were suprised, if not shocked, at the sweeping nature of the directive. They too wondered what it would mean in the future.

Little Hope in Loopholes

Little hope was taken from the apparent "loopholes" in the order—that this limitation on Army operations did not prevent it from "making feasibility studies." Again questions. "What did this mean? Maybe the Army could make three or four missiles and test them, but why do it, if they could never use them? Better to spend research money on projects included in roles and missions."

But talking and walking about, you got the feeling from top researchers, production men, salesmen and military leaders alike that this wasn't the end of the affair. There were guesses that Wilson would think again when he realized the full impact of what he risked. And there were convictions that Congress in the next few months would have something to say on the matter as well. As one disgruntled ARS member put it: "Wilson may have settled an argument but he started a fight."

ARS Meeting Details

Now, covering the week's order of scheduled business in a little more detail, members got a preview of some new high-altitude sounding rockets.

W. C. House, C. H. Dodge, R. D. Waldo, A. Schaff, J. L. Fuller, and O. J. Demuth—from Aerojet-General Corp., Azusa, Calif., detailed four future research rocket systems.

Douglas Aircraft Co., Santa Monica, Calif., is believed to have a *Rockair* system under development and almost ready for launching, the Aerojet group reported. This system uses an airplane as a launching platform for any suitable sounding rocket. The plane zooms into a vertical attitude, fires the rocket upward.

System No. 2 is designed to extend the 250-mile summit altitude potential of the present *Aerobee* research rockets to above 300 miles. The new system would employ an advanced vehicle similar to the *Aerobee* but with four thrust chambers which would fire two-at-a-time.

A third vehicle known as the *Spaerobee* simply adds a second stage to the *Aerobee*, pushing the rocket to a summit altitude of 350 miles with a 40-pound payload.

System No. 4 is a more general concept, concerned essentially with a staged vehicle. "Using presently available solid propellant rockets," stated the Aerojet planners, "staged vehicles can be assembled yielding almost any desired performance."

Homer E. Newell, Jr., Naval Research Laboratory, reported that a number of new sounding rockets are under development. And, said Dr. Newell, less expensive solid propellant vehicles comparable in altitude and payload capabilities to the liquid propellant *Aerobee-Hi* may be available in the near future.

John W. Townsend, Jr., Naval Research Laboratory, and Robert M. Slavin, Air Force Cambridge Research Center, described two new versions of the *Aerobee-Hi* expressly designed for upper air research in the forthcoming IGY Program.

Leslie M. Jones and Nelson Spencer of the University of Michigan, William Stroud of Fort Monmouth Evans Signal Laboratory, and

Confidential friends at ARS annual meeting.

ARDC's Col. Wm. O. Davis presented one of 48 technical papers.

Warren Berning of Aberdeen Ballistic Research Laboratory reviewed the development of the new solid propellant sounding rocket, the *Nike-Cajun,* reported that work with solid propellant sounding rockets is just beginning. Interesting developments in this field are underway, they said, and will be completed soon.

Rocket transport seen feasible

Use of a rocket vehicle as a transport capable of spanning the 3,000 miles between New York and Los Angeles in a little less than an hour has been visualized by many rocket experts for some time. G. Harry Stine of White Sands Proving Ground said that such a vehicle could be built within the next five years and proposed a possible design for a prototypal craft.

It would look similar to the Bell X-2 or the Douglas Skyrocket. Of its 65,500-pound total take-off weight, 43,500 pounds would be propellants, 20,550 pounds structural weight, and 1450 pounds would be payload.

Powered by liquid oxygen and gasoline, the rocket would cover its 1,500-mile range at speeds up to Mach 7, at altitudes up to 155 miles. This proposed vehicle, said Mr. Stine, would be an excellent research tool, an important first step in transcontinental rocket transport.

In coping with high temperature flight, one of the most promising developments, according to Robert R. Freeman of Climax Molybdenum Co., is the creation of four new arc-cast molybdenum alloys. These alloys, they claimed, have higher useful strength at temperatures over 1,600° F than any other material now known, and for temperatures over 2,400° F, ceramic and vapor-deposited molybdenum-disilicide coatings show promise of long time protection where mechanical impact, high stresses or severe thermal shock is not involved. Only recently made commercially available, the four alloys can be easily produced and fabricated.

George L. Macpherson of General Electric reported success in the solution of those problems relating to development of the *Vanguard's* first-stage power plant. First delivery of the engine, known as the X405, was made on schedule last month.

Rocket Exhibition

A special exhibition on missiles and rockets under the auspices of the American Rocket Society was featured at the 22nd National Exposition of Power and Mechanical Engineering at the Coliseum.

Nineteen exhibitors, including the prime contractor and subcontractors for all three stages of the Navy's Project Vanguard, had displays (Martin Company, General Electric Company, Aerojet-General Corporation, and Grand Central Rocket Company). Other exhibitors included the company holding systems responsibility for the Air Force IRBM and ICBM missiles (Ramo Wooldridge Corporation); the company building the rocket engine for the ICBM (Rocketdyne, Division of North American Aviation); and the country's oldest rocket engine manufacturer (Reaction Motors, Inc.).

Unique Grand Central stand at Coliseum power show stresses VANGUARD challenge.

Redstone Mortgage Crisis Eased by Local Group

Determined community action by citizens of Huntsville, Ala., has broken the tight mortgage money shortage that threatened to halt urgently needed new housing for many of Redstone Arsenal's 9,000 civilian workers.

In September, the Federal Housing Administration designated Huntsville as an emergency area and authorized "Title 809" loans of 30 years, very low down payments and 4½ per cent interest. This action had been requested by Alabama's Senator John Sparkman and Huntsville and Redstone officials. Hundreds of Redstone employes applied for loans under the new dispensation but only a sparse number was able to obtain financing through normal commercial channels.

Five Huntsville citizens and four financial companies banded together in this crisis to form a new firm to buy, sell and service FHA and Vet-

erans Administration-guaranteed mortgages. Quick Washington approval of the new firm was given by FHA at instigation of Sen. Sparkman, and loan applications are now being processed in Huntsville. Profits of the new company will be very narrow, as the 4½ per cent loans will be discounted at from 1½ to 2 per cent through the Federal National Mortgage Association, a government-sponsored agency which serves as a secondary mortgage market.

Redstone Personnel Passes 12,000 Mark

The expanding scope of missile and rocket activities at Redstone Arsenal, Huntsville, Alabama, is indicated by announcement that the military and civilian personnel at its three units has now passed the 12,000 mark and is still expanding. This includes the Arsenal itself, the Army Ballistic Missile Agency and the Ordnance Guided Missile School. This is an increase from 8,700 at the same time last year. It is very near the total employment at the same site during World War II when the Arsenal was concerned with manufacture of explosive ammunition.

UFO Board Set

The National Investigations Committee on Aerial Phenomena has named a nine-man board of governors to direct its effort to provide "more honest information" about flying saucers and space flight.

The committee is a non-profit organization set up recently to provide the public with a "broader understanding of such aerial phenomena as unidentified flying objects and the technical problems of space flight."

Elected to the board were:

Dr. Charles A. Maney, professor of physics, Defiance (Ohio) College; Rear Admiral D. C. Fahrney, retired; A. M. Sonnabend, president, Hotel Corporation of America, Boston; the Rev. Albert H. Baller, Robbins Memorial Congregational Church, Greenfield, Mass.; Brig. Gen. Thomas B. Catron, retired; Frank Edwards, radio-TV commentator, Indianapolis; Talbot T. Speer, Speer Foundation, Baltimore; the Rev. Leon C. Levan, New Jerusalem Christian Church, Pittsburgh, and Robert Emerson, Nuclear physicist, Kaiser Aluminum Company, Baton Rogue, La.

Admiral Russell Quotes m/r To Predict A-Rockets Soon

As the main speaker of the Honors Night dinner of the American Rocket Society's 11th Annual Meeting in New York, Navy Bureau of Aeronautics Chief Rear Admiral James S. Russell, USN, forecast the advent of successful atomic power for space flight in the not-too-far-distant future. In his prepared text* he said: "I have read in MISSILES & ROCKETS magazine that the Atomic Energy Commission is working on rocket propulsion. With you (ARS) and the Atomic Energy Commission working in the same science, it takes practically no extrapolation to envision safe and non-poisonous atomic fuels and extra-mundane use of atomic power for casual space travel . . . I expect these things sooner than we would normally expect them to happen."

He also predicted the wedding of rocket and turbojet engines for manned interceptors. "The manifest answer is to blend the capabilities of the turbojet and the rocket engine in a combination power plant . . . Thus with rocket power we are giving the airplane greater reach and maneuverability, as with rocket power we give its armament greater reach and flexibility of employment."

Showing how missiles are being adopted into the Navy, he said that there are now 10 *Regulus* ships operational, including submarines, and that five years from now there will be at least eight *Talos* cruisers, 22 *Terrier* ships and 17 *Tartar* ships. And he looked forward to delivery for operational use of the joint Army-Navy 1500 mile IRBM *Jupiter,* thus perhaps taking a little of the sting out of Defense Secretary Wilson's recent controversial "roles and missions" directive.

**In the actual delivery of his speech at the ARS dinner, Admiral Russell deleted the words "MISSILES & ROCKETS". ARS Secretary A. C. Slade said after the dinner that she and ARS Board Chairman Andrew G. Haley had asked the Admiral beforehand about the wisdom of mentioning m/r at the ARS Honors Night dinner. However, in the release of the speech from the Department of Defense, Washington, D. C., to the world's press, the wording was that quoted above.*

New Avco Facility

Dr. Arthur Kantrowitz (left), director of the Avco Research Laboratory, and Dr. Lloyd P. Smith, president of the Research and Advanced Development Division, survey landscaped model of the permanent facility to be built by Avco Manufacturing Corporation. The research, administration, development and fabrication complex is on a 100-acre wooded site in Wilmington, Mass.

Three *Nike* Support Units are Activated At Redstone

Three *Nike* guided missile direct support detachments have been activated at the Army Ordnance Guided Missile School, Huntsville, Ala. They are the first such units to be activated here and will broaden the range of instruction available to students in the rapidly growing service training school. They also will expand the number of trained personnel qualified to give instruction to other Army missile units as they are activated.

Their 13-weeks training cycle will include technique of missile fire, acquisition radar and computer, track radar, internal guidance, mechanical repair and launcher control.

Scientist Sees Boom In Transistor Output

Rapid growth of the transistor industry and prospects for the future of solid state physics were highlighted in information disclosed at the second annual meeting of the IRE Professional Group on Electron Devices recently in Washington, D.C.

Dr. William Shockley, director of Shockley Semiconductor Laboratories told a PGED assembly that about 13 million transistors would be produced in 1956. He estimated 40 million in 1957.

Shockley is generally credited with development of practical transistors while he was with the Bell Telephone Laboratories. He said that although practical transistor operation to 100 mc is feasible now, developments in the next few years would enable operation in the kilomegacycle range.

Advanced ideas on possibilities of semiconductors was fore-told by Dr. J. T. Wallmark, Radio Corp. of America Laboratories who disclosed data on a new light-sensitive device that could be used to guide missiles by sunlight with unheard-of accuracy.

RCA has developed a novel photocell based on voltage produced by a semiconductor junction when light is focused on it through a lens. Wallmark has found that moving the position of the light gives a varying voltage polarity along the junction from side-to-side.

Putting this "lateral voltage" to work, it was found an angular motion of the light smaller than 0.1 second of an arc can be measured. This angular sensitivity is so great, Wallmark said, that such a cell could detect the center point of the sun with "great accuracy" and form the heart of an automatic navigation system using the sun as guide.

AAS Controversy

In protest against American Astronautical Society management several well-known society directors recently resigned en masse. Following the earlier resignation of Dr. Robert W. Berry and Dr. C. C. Adams of National Research and Development Corporation, the following directors now have also quit: Dr. Wernher von Braun of Army Ballistic Missile Agency; Dr. S. Fred Singer of University of Maryland; James B. Cullum of Eastman Dillon; Krafft A. Ehricke of Convair Astronautics; Frederick I. Ordway, Heyward E. Canney, Jr. and Ronald C. Wakeford of General Astronautics Corporation. This leaves the future of the AAS very much in doubt.

B-52 As *Regulus* Missile Launcher

The Boeing B-52 may be modified to carry large missiles that will enable them to release their payload many miles from their target. Tests run with the Chance-Vought *Regulus* launched from the B-52 have shown that this combination is feasible. An AF concern with the B-52 is that not only is it five times the radar target the B-47 is, but its altitude over target, 50,000 feet, is such that it can be jumped from above by the Russian MiG-17. Also, with advances made in ground-to-air missiles, altitude alone, whether it's 50,000 or 100,000 feet, offers little protection.

The *Regulus* may be particularly adaptable to this operation. Its folding wings would probably enable it to be entirely contained within the B-52's massive bomb bay. The *Regulus* II will be supersonic and will have its own "lock-on-target" self-contained guidance system.

Expert Charts Future of Big Brother Satellite

General Electric rocket expert R. P. Haviland recently predicted that "television transmission will be the satellite's first major communication service." Briefing GE engineers on the practical future of satellites, he said the advent of man-made space stations will make it possible to simulcast programs all over the world without the use of coaxial cables or transmission systems.

Haviland, who was project engineer on the *Bumper* two-stage rocket that set a world altitude record of 244 miles in 1949, said satellites can serve as relay stations in a world-wide television system in the same way that an airplane recently relayed live TV programs from Cuba.

This is a dream long held by television network operators. Long before the coaxial cable and microwave relay stations came into their own. Not-so-dumb artists and engineers proposed elaborate networks of specially-equipped cargo planes orbiting on station continuously during each broadcast day. This was one of the first plans offered for nationwide TV coverage. But, other systems less dependent on weather and, over the long haul, less expensive came along and they were never developed.

However, the distances covered by satellites could be much greater. TV transmission is line-of-sight, and is not limited by signal strength. Being very short wave, neither would it be bothered by the ionsphere.

Haviland, now a flight test planning engineer with GE's Missile and Ordnance Systems Department, Philadelphia, said a world-wide TV system could be established with four satellite stations traveling 4,000 miles high.

They would be equally spaced about the earth and be visible at any instant from any point in the earth's equatorial region. A TV signal could then be transmitted from any ground location in this region to the nearest satellite and relayed from satellite to satellite. At the proper location, the signal would be retransmitted to a receiving station on earth.

Equipment that the satellites would have to carry for this system would be good quality receivers and transmitters. The major ground equipment needed would be large directional antenna.

Haviland continued that Project Vanguard is now under way. Yet only 10 years ago an earth satellite was strictly science-fiction material. "If large satellite relay stations could be established in an orbit 22,300 miles above the earth, then the world-wide TV system could be simplified."

He explained that at this height only three stations would be needed to cover the earth. He also forecast that satellites will be used for mapping primarily to determine the shape of the earth. This would significantly aid both astronomers and navigators.

Haviland also said that the day would come when satellites would be used in weather forecasting. He pointed out that they could view cloud coverage over extremely large areas in a short time.

Obviously, too, they would be useful strategically in watching and reporting enemy build-ups, industrial expansion, etc.

However, in the final analysis, the uses to which post-Vanguard "big brother" satellites will be put will depend largely on their initial cost of installation and their subsequent cost of maintenance in comparison with alternative means of accomplishing the same thing. Strategically, there may be no substitute for the satellite in accomplishing certain military objectives. And since the military services traditionally are not concerned with the profit motive, big satellites will find many military uses.

However, their role in such things as TV relaying will have to successfully pass close cost examination before anyone signs the first contract for hardware.

Rocket expert R. P. Haviland thinks a "Big Brother" satellite will facilitate world-wide television coverage.

Murphree: Better AAM Weapons Needed

First public disclosure that missiles would be used to defend U.S. bombers against attacking enemy aircraft was made recently by missile czar Eger Murphree when he cited the need for "more effective" air-to-air missiles for that specific purpose.

The need for air-to-air missiles will continue, Murphree explained, since the need for long range interceptor planes "will exist for a long time." While the surface-to-air missile "will largely displace short range interceptor planes," he noted, it "will not take over all the functions of the interceptor aircraft."

The Special Defense Assistant for Guided Missiles outlined general missile requirements before the 11th Associates' Day of Stanford Research Institute in San Francisco. In specific areas, Murphree told the group:

1. The *Nike* I and *Terrier* will be "gradually" outmoded as aircraft designs advance because of need for greater range and altitude capability. But their replacements—the *Nike* B and *Talos*—"are real improvements" and "will meet our needs for a while" in surface-to-air developments.

2. High speed enemy ramjet and long range ballistic missiles will present a dual defense problem. The new surface-to-air missiles will "not be effective" against them nor can radar pick them up at "sufficiently long distances" for defense missiles to be effective.

3. The recently announced Navy *Sidewinder*, which he confirmed the Air Force also would use, was labeled "quite a simple missile" but it "has certain limitations in use." Also in the air-to-air category, "substantial improvements" are being made to the Navy *Sparrow* and the Air Force *Falcon* and future developments "will represent an extension along present lines."

4. Long range surface-to-surface missiles "are not likely to have the requisite accuracy" essential for hitting "hard targets where bombs must be placed essentially on the target." But they will be effective against industry areas "where a very high degree of accuracy is not required."

5. Murphree disclosed for the first time that improvements are being made to the *Matador*, presumably in the guidance area. While similar to the *Regulus*, the *Matador* improvements are "along somewhat different lines than the improvements being made in the *Regulus* missile."

Increased Accuracy by Refinement

In a summation of research needs, the Defense official found a "heavy incentive for increasing accuracy." "New ideas," he said "are needed to fully obtain what is desired," although "much can be done" to increase accuracy "by refinement of present developments."

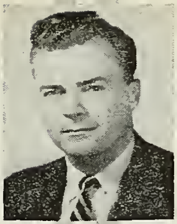
Quarles, Carlson in Redstone R&D Posts

Two significant appointments to research and development posts at Redstone Arsenal and the Army Ballistic Missile Agency, Huntsville, Ala., were announced in November.

Dr. Gilford G. Quarles, formerly director of the Ordnance Research Laboratory at Pennsylvania State University, becomes scientific and technical consultant on the staff of Maj. Gen. J. B. Medaris, commanding the ABMA, which developed the *Redstone* missile and now is pressing development of the "*Jupiter*" intermediate range ballistic missile. At Penn State Dr. Quarles directed Navy weapons research, specializing in underwater ordnance. In World War II, he was responsible for research, development and engineering of a homing torpedo.

Dr. William S. Carlson, of Frankford Arsenal, Philadelphia, is named chief of Redstone Arsenal's newly created Air Defense Laboratories, a part of the R&D Division of the Arsenal. At Frankford, he was in charge of research and development of the Fire Control Instrument Group.

The new Air defense Laboratories at Redstone perform supporting guided missile research and development in the fields of detection, acquisition, fire control, guidance and control systems and in countermeasures against all forms of enemy effort to prevent proper functioning of missile systems. It also is concerned with planning long range programs of research and development for established and future missile systems.



Rocket Trends

By Erik Bergaust

WE WERE RATHER PLEASED when LIFE magazine called us up some days ago, asking if we could provide the original art work that accompanied our little story on how the Russians—by implication—are boasting about their forthcoming IGY satellites. Those who recall this story from our November issue will remember that some Russian engineer had copied Dr. Fred Singer's MOUSE orbiter. Aside from this, we might add that this magazine, i. e., MISSILES & ROCKETS, is hard at work trying to round up as much authentic information as possible about Russian rockets and Russian astronautics trends for a forthcoming issue. We have quite given up the idea of going to Russia for first-hand information. Not having heard from the Soviet embassy here in Washington for some months, and since it is now more than one year since we applied for a visa, we take it for granted that we shall never be honored by a visit to Russian engineering and research centers. Indeed, that story in our November issue is not going to help us get any visa. But we still shall come out with a "Russian issue."

★

WHAT MAY TURN OUT TO BE THE WORST ERROR IN JUDGMENT in American technology was announced by Secretary of Defense Wilson recently, when he heralded that USAF has been picked to conduct the country's intermediate-range missile activities, leaving the experienced Army ballistic missile experts cold (see page 70). One particular aspect of Wilson's directive—which does not seem to have been taken into consideration—is the obvious fact that American missile engineering as a whole may be set back several years.

★

ADVERTISING AND EDITORIAL content don't mix we have been told since way back. Nevertheless, we cannot help having a noticeably proud feeling about the 20-page insert following this column. We are humble in our appreciation for the advertiser requesting this particular position in the magazine. Furthermore, the ad—as such—leads us to believe that liquid oxygen isn't dead. M/R will follow this up in the next issue.

★

THE AIR FORCE did not have any *Navaho* pictures to release at press time. However, Henry Simmons' fine story (page 77) on North American and their forthcoming intercontinental missile has been dressed up with an Apache/Navaho totem pole to indicate what kind of sophisticated blow must be contemplated from this side of the ocean in case someone decides to hit the war path. But everybody seems to know what the *Navaho* looks like. How about it Air Force? We feel certain the Russians know what it looks like, and that they know what this missile is capable of—with a nuclear warhead. And that's pretty much the point, anyway . . .

★

WE HAVE FOLLOWED WITH GREAT INTEREST the British Interplanetary Society in its efforts and struggles. We have somewhat tried to grasp their troubles each time we have visited the Secretary's crowded and antique 12 Bessborough Gardens office in London; we think the BIS is a progressive organization. However, it was with mixed feelings that we read a BIS press release a few days ago, with information on "*the full story of the way British engineers helped lay the path for America's artificial satellite.*" The release refers to an article in SPACEFLIGHT dealing in part with the "resemblance" of the *Vanguard* design and a British satellite proposal made 5 years ago. A U.S. Navy friend says this doesn't mean the British taught us how to design the *Vanguard* vehicle. We should think not.

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missiles and rockets
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Ballistic Missiles and Management

By Major General B. A. Schriever
Commander, Western Development Division, USAF

THE AIR FORCE ballistic missile program encompasses the largest concentration of men, money and materiel on a science-industry military basis that has ever been achieved. The end product required—an operational intercontinental ballistic missile at an early date.

To give due and just credit to the contribution which science and industry is providing the Air Force in this dynamic program requires some explanation of the method used by the Air Force in selecting its scientific and industrial associates for the ballistic missile task, how it organized for the job, and the degree of success achieved in the program to date.

The factors effecting the acceleration of the Air Force long-range ballistic missile program were primarily scientific and technical.

The thermonuclear breakthrough in 1952-1953 was a major break. The possibility of high yields in reasonable packages meant that accuracy requirements could be relaxed, that it was now technically possible to develop a reliable guidance system, and that the overall weight of the missile could be considerably lessened.

These factors brought the ICBM weapon system to the forefront as an attractive manageable proposition. The ICBM, an impractical device in the early atomic weapon age, now assumed new military worth and importance. Based on these facts and on lengthy meticulous study and analysis, sweeping changes in the Air Forch approach to the ICBM development was to take place.

These studies were conducted by the Air Force's Strategic Missile Evaluation Committee, headed by Prof. John von Neumann, Atomic Energy Commissioner and an eminent scientist, and composed of eleven of the Nation's top scientists, many of whom had worked on the A-Bomb development.

To implement the letter and spirit of the committee recommendations, the Secretary of the Air Force directed the acceleration of the ICBM program development. The program was assigned the highest priority in the Air Force with precedence over all other programs, and the Air Research and Development Command was directed to establish an organization in the field which would exercise overall responsibility and authority for the program.

In August 1954, the Western Development Division of Headquarters ARDC was established in Inglewood, California. WDD was to have responsibility and authority over all aspects of the program with the specific purpose of reorienting and accelerating the ICBM program in order to achieve the earliest possible operational capability.

By January of 1956, the Air Force Ballistic Missile Program had been expanded to include the IRBM THOR. The ICBM program already had under development all the subsystems such as propulsion, guidance and nose cone, which were required for the THOR. Therefore, only the Douglas Aircraft Company, which has the airframe, assembly and test responsibility, was added

to the list of industry contractors. Tapping the ICBM program provided a special opportunity for maximum saving in development time and money.

The establishment of WDD by the Air Force was indeed a unique and important management step. It marked the first time that the Air Force would retain full and complete management responsibility over a major development effort.

Three Management Elements

This overall management organization consists of three major elements operating as an integrated team. The supervising element is the Western Development Division of the Air Force's Air Research and Development Command. The technical staff of WDD is comprised of a corps of very highly qualified handpicked officers of which more than one-third have been awarded Ph.D's and Master Degrees. Many of them are experienced missile experts who have proven their capability and technical competency on other Air Force missile projects.

The second major element is the Ballistic Missile Office of the Air Force's Air Materiel Command, which, with Brig. General Ben I. Funk in charge, exercises contracting and procurement responsibility for the entire program.

General Funk directs the activities of the AMC Ballistic Missile Office, while also serving as a Deputy Director of Procurement and Production of the Air Materiel Command. In this capacity he also serves as an Assistant to AMC Commander General Rawlings, and as such has direct access to all of the Air Materiel Command Staff in support of the program. He also has directive authority over those Air Materiel Areas concerned with the ballistic missile program.

In addition, General Funk has special plant representatives who answer to him in all of the contractor plants in the program and who are able to supervise and expedite all actions involved in the implementation of program contractual requirements.

The third important element is the Guided Missile Research Division of the Ramo-Wooldridge Corporation, selected to provide weapon system engineering and technical direction to the nationwide industrial team participating in the program. Ramo-Wooldridge also provides technical supervision of the entire Air Force ballistic missile program by an industrial firm, was adopted by the Air Force in order to gain the services of an organization which possessed outstanding scientific and technical talent as well as proven systems engineering know-how.

By mutual contractual agreement between Ramo-Wooldridge and the Air Force, Ramo-Wooldridge emphasis is confined solely to technical direction and weapon systems engineering responsibilities and precludes Ramo-Wooldridge participation in any hardware phase of the weapons under development. Thus, the WDD/BMO/R-W team operates as an integrated organization to expedite the completion of the vital ballistic missile program.

A novel feature of the WDD/-BMO/R-W management approach was the formation in 1953 of the Intercontinental Ballistic Missile Scientific Advisory Committee to the Secretary of the Air Force. Composed of outstanding men in science and engineering and under the Chairmanship of Prof. John von Neumann, this committee has proven to be of inestimable value in its counseling capacity to the WDD/BMO/R-W organization, in guiding working relations with the Atomic Energy Commission, and in guiding the technical study and analysis of major problems connected with all phases of the program.

The Scientific Advisory Committee now functions as the primary scientific advisory group on ballistic missiles to the Secretary of Defense, and in this capacity provides technical advice and counsel to all three services.

Industrial partners completing the industry-science-military team's efforts are geographically located from coast to coast in virtually every state in the Union.

More than 30,000 persons are actively employed by these 17 major contractors. Numerous subcontractors and small businesses employing thousands more in support of this vital national effort.

A program of such scope necessarily needs many supporting facilities—facilities of size and complexity heretofore unknown. For example, large rocket engines to power the missiles had to be designed, developed, and tested—requiring new and unique testing facilities. Many of these new test facilities are in themselves outstanding achievements.

Detailed preliminary technical studies and systems analyses pointed strongly to the wisdom of instituting some form of industrial competition to insure availability and reliability of intricate components and subsystems. Early in the program WDD adopted a two pronged philosophy of competition—competition among contractors and alternative (not parallel) technical approaches.

The alternative technical approach is patterned after nuclear weapon development which has proven to be so successful. The principle of selective competition was adopted in the choice of the prime contractors. It was felt that such a philosophy would accomplish an end result sooner, better, and in the end cheaper, as well as provide the optimum technical backup.

The Air Force Ballistic Missile Program is a single program for which three missile configurations will emerge, two for the intercontinental mission and one for the intermediate range mission. These are not separate independent missile system approaches as often implied. While missile configuration and staging approaches differ physically and technically, there is a very high degree of interrelations and interchangeability among the subsystems (propulsion guidance and nose cone) being developed. Also the test program for each missile configuration compliments the other and even here alternate test approaches are being taken.

The concurrent development and production of the Air Force's Ballistic Missile Program under the management supervision of the WDD/-BMO/R-W team is an integrated approach without precedent. The program is on schedule. Milestones are being met and we are confident that they will continue to be met.

The Air Force firmly believes in the policy of utilizing the demonstrable effectiveness of all elements of U.S. science and industry. Accordingly, the strongest scientific-industrial-military team possible has been assembled by the Air Force in all fields of ballistic missile requirements in support of this, the nation's highest priority program.

Without this philosophy and without the wholehearted response of science and industry, the task could not be accomplished. ★


MATADOR TM-61

SM 65 ATLAS

No picture available. Missile is approx. 6 feet in diameter, more than 80 feet long, nose is blunt-shaped.

WS 107 TITAN

Unlike SM 65 ATLAS. Both ICBMs believed to be two-stage liq. rocket missiles. Nose cone represents third stage.


GAM 63 RASCAL

US Air Force Missile Arsenal

Manufacturer	Designation	Powerplant	Remarks
Surface-to-Surface			
Convair	ATLAS SM-65	North American liquid rocket	ICBM, thermonuclear warhead
Douglas	THOR WS-315A	North American liquid rocket	IRBM under development
Martin	MATADOR TM-61A/B	Allison J33-A-17 + solid boosters (later versions to have more powerful J33)	Guided bomber; also TM-61B (longer), TM-61C and TM-61D. In service
Martin	TITAN WS-107	Aerojet liquid rocket	ICBM under development
North American	NAVAHO SM-64	2 Wright ramjets + North American liquid rocket as booster	Under development in several versions
Northrop	SNARK SM-62	P & W J57 + 2 boosters of 33,000 lbs. each	In production
Surface-to-Air			
Bendix/ McDonnell	TALOS L	McDonnell ramjet + booster	In production; also TALOS SAM-N-6 and TALOS-W for Navy and Army
Boeing	BOMARC IM-99	2 Marquardt ramjet + Aerojet rocket	Missile-carrier missile (FALCONS)
Air-to-Surface			
Bell	RASCAL GAM-63	Liquid rocket	Launched from B-52 or B-58
Air-to-Air			
Douglas	DING-DONG	North American liquid rocket	Under development, atomic warhead
Hughes/ Philco	FALCON GAR-98	Thiokol solid rocket	In production. Also FALCON 2 and FALCON 3
Fairchild	GOOSE	Fairchild J83 or GE J85	ECM vehicle, no warhead
(Philco	SIDEWINDER AAM-N-7	Solid rocket	Operational, infra-red homing; NAVY MISSILE, might be used in AF fighters, such as F-104)


SM 62 SNARK

DING-DONG

High-punch air-to-air missile with atomic warhead. No picture available.


TALOS


TM 61B MATADOR

WS 315A THOR

No picture available. IRBM missile somewhat similar to Army's liquid-prop. JUPITER.

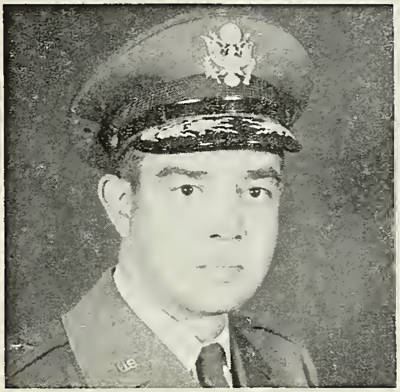

GAR 98 FALCON

SM 64 NAVAHO

Picture to be released soon. Liq. rocket booster and two ramjets. Canard stabilizers up front. Supersonic, 5,000 mile range.


IM 9

Key to Survival: Missile Research and Development



By Brigadier General Don R. Ostrander
Assistant Deputy Commander for Weapon Systems, Headquarters, Air Research and Development Command

IN THIS modern age of supersonic planes, missiles and rockets, we no longer can depend upon sheer quantities of men and weapons to bring us victory in any future war. We cannot match the Soviets either in manpower or numbers of weapons, nor do we wish to do so.

Quality and superiority of our weapon systems, then, are the keynotes of our air research and development program. The fact was emphasized last year by the Secretary of the Air Force when he appeared before the Senate Armed Services Committee. At that time, he said, in part:

"... The Air Force has no intention of getting into a numbers race with our potential enemy. We are determined, instead, to maintain the qualitative superiority of the Air Force. Research and Development is the most important activity within the Air Force and industry to insure maintaining that position."

Research and development constantly gives birth to weapons of increasingly destructive power. But the whole evolution of explosives and the vehicles which have carried or launched them shows that, in time, each weapon system was superseded by a new and superior one.

An analysis of weapons from the mace to the longbow, from the musket to the H-bomb, reveals, in truth, that "past is prologue." The analysis provides another truth. As always, military men strive to propel destructive power to greater distances at ever-increasing speeds, in their never-ending search to find the "ultimate" weapon. But never yet has that goal been attained.

Before we take a philosophic approach to the future of guided missiles, let's review how we in the Air Research and Development Command plan, manage, and provide the technical leadership for the Air Force guided missile development program.

In carrying out our mission, we receive the necessary resources and directives through a channel which starts with the Congress which appropriates the money to support our operations. The channel then flows through the President who signs appropriation bills. When this is accomplished, the Department of Defense assumes the leadership for the administration of the overall operations.

At the Department of Defense, a special assistant for Guided Missiles coordinates all such programs for the three services of our Armed Forces. Funneling down to Air Force level, the control channel extends through the Secretary of the Air Force to the Chief of Staff who has an Assistant Chief of Staff for Guided Missiles and a Dep. Ch. for Dev. who, in turn, acts as his primary advisor on all Air Force guided missile matters.

We now have reached ARDC—the operational level for the program. ARDC is responsible for planning and managing all Air Force guided missile development projects. Here at headquarters in Baltimore, Maryland, an assistant for Guided Missiles, reporting directly to the Commander, coordinates all activities of guided missile projects.

Special Organization for ICBM Development

Because of the accent today on the ICBM (Intercontinental Ballistic Missile), a special organizational structure has been superimposed on the basic structure to manage the Air Force program in the area of ballistic missile development. The special organization is the Western Development Division with headquarters in Los Angeles, California. Its commander has been delegated considerable authority to speed up this very vital and high-priority development program.

Several committees—made up of

both military and civilian experts—are in existence to speed up decisions on the review of various facets and phases of the program.

In carrying out the Command's responsibilities for the research and development programs for guided missiles, each of our major research, development, and test centers plays an important part.

Three other organizations, which report directly to the ARDC Commander, are integral components of the command and make major contributions to any end product in the guided missiles programs. They are:

The Armed Services Technical Information Agency (ASTIA), located in downtown Dayton, Ohio, which provides centralized technical information services to all Department of Defense agencies and their contractors. ASTIA is responsible for collecting and cataloging research and development information and disseminates it on a "need-to-know" basis.

The Air Force Office of Scientific Research (AFOSR), located in Washington, D.C., which conducts an exploratory research program in the physical and bio-sciences through contractural arrangements with profit and non-profit institutions and universities. The purpose of the AFOSR program is to provide new scientific knowledge, and to recognize and report scientific achievements, the application of which may result in new concepts of air warfare or new air weapons.

This Office of Aircraft Nuclear Propulsion, located in Washington, D.C., which is responsible for monitoring the development of nuclear propulsion for aircraft.

All three organizations, directly or indirectly, contribute to the sum-total input which furthers our guided missiles project progress.

All units mentioned work together as a team within the ARDC structure. But in addition to our operational command teammates, such as AMC, we have others—equally active, equally important. We work closely with industry and the universities and research groups of the Nation because it is—in this scientific, technical and production potential—that our future airpower will be built.

Perhaps because of over imagination in writers and the dramatization of the capabilities of the ICBM, press and public attention centers on this vehicle. But ARDC's responsibility is not confined to this weapon alone. The Command is concerned with the development of a whole spectrum of weapons which are essential in carrying out the roles and missions of the Air Force. Among these are:

The guided aircraft rockets which can be launched offensively from our interceptors against invading enemy targets or defensively from our own invading bombers against enemy interceptors.

The interceptor missiles which can reach out at long range, as compared with anti-aircraft and artillery missiles, to intercept and destroy incoming enemy bombers these are area defense weapons as contrasted with local defense weapons.

The air-to-surface guided missile for use either in the tactical role at shorter ranges in support of the ground forces or in a strategic role at long ranges to apply airpower to the military and economic structure of an enemy.

Several categories of missiles are being developed in this area. One is an airplane type of winged missile which follows a path parallel to the earth's surface and flies within the earth's atmosphere to its target.

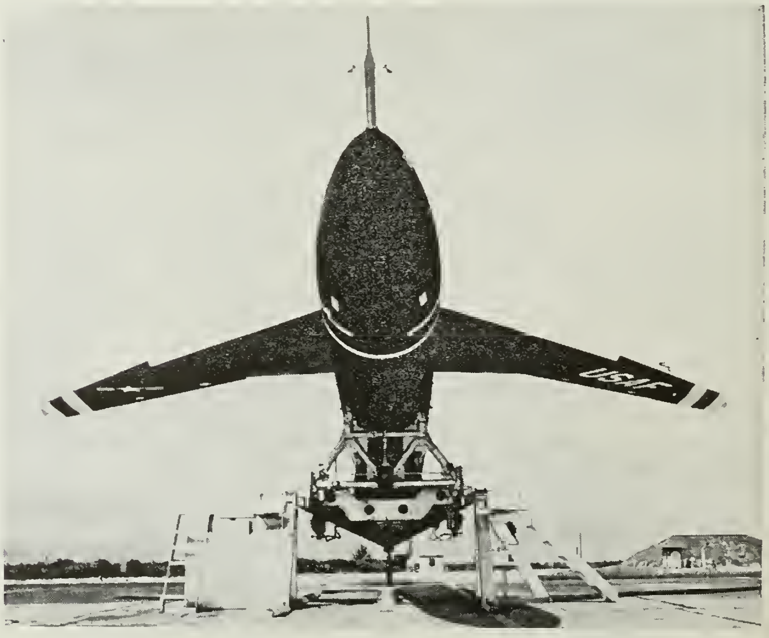
The other category is the ballistic missile which is guided into space and follows a ballistic flight path to its target. Both of these types are capable of delivering atoms and thermo-nuclear warheads.

All of this effort, then, is directed toward giving us a versatile and more effective family of guided missile weapon systems, either in combination with manned weapon systems or complementary to them.

A little more than a decade after the first powered flight by the Wright Brothers, a small group of aviation-minded men, with vision and faith in the future, began promoting the development of our first guided missile. They called it a "Flying Torpedo." Heading the dedicated group were Orville Wright, "Boss" Kettering, Elmer Sperry and General "Hap" Arnold—all men who occupy an enviable niche in Aviation's Hall of Fame.

Dogged effort on the part of the group resulted in a successful launching of the vehicle in September 1919. Since the launching of the Flying Torpedo, we've made tremendous strides in all phases of the art of aerodynamic, electronics, and propulsion. Compared with this early

Northrop's SM 62 SNARK intercontinental missile is outdated. But the Air Force has learned much and has gathered valuable information from SNARK experimentation on how to design tomorrow's more sophisticated ICBM weapons.



effort, however, our guided missiles of today are completely automatic weapons of superb sophistication and complexity, and tremendously of superb and increased capability. Their future potential is limited only by men's imagination. And we, students of modern weaponry, certainly could never be accused of being unable to see beyond present horizons.

We readily see, then, that our interest in guided missiles dates back to World War I. True, our efforts prior to and even during World War II, in the rocket and missile fields, though continuous, necessarily were limited.

On a crash basis, we did develop the famed bazooka, which helped materially in defeating the rampaging Rommel in Africa. We also crash-programmed the 4.5-inch barrage rocket used so effectively in the Pacific. During the war, the Tiny Tim and the 5-inch HVAR, the rocket-propelled mineclearing snake, and aircraft JATO—all were entered into our armament inventory.

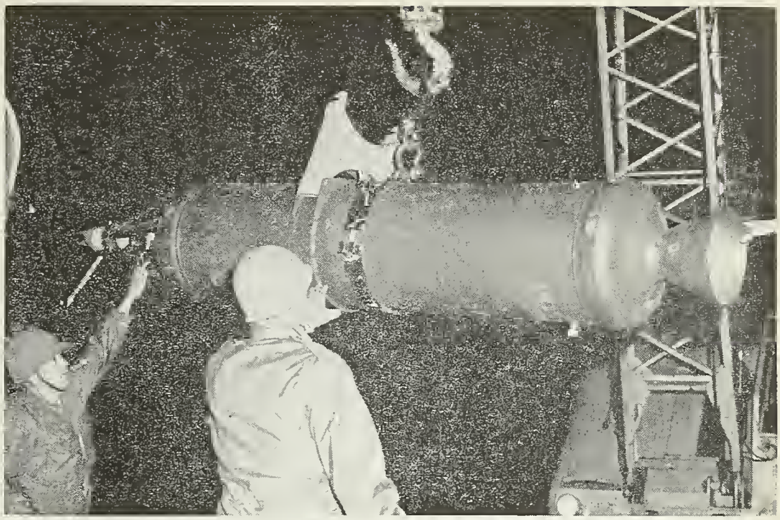
In 1942, liquid-fueled V-2 rockets were successfully flight-tested by the Germans. Between 1944 and 1945, they produced about 6,000 V-2's. Of this total, approximately 3,600 were launched against allied targets.

Compared with the spectacular German effort, however, our pace was pedestrian. The Germans first developed the "Fritz X," later the semi-guided V-1 missile, and lastly the V-2 ballistic missile. Our own development in these areas was virtually nonexistent.

For some time after World War II, progress centered on the development of liquid-fueled rockets. Currently, the Air Force, as well as the Army and Navy, are researching and developing missiles using liquid rocket propulsion.

Since this article is a philosophical approach to the research and development of rockets and missiles, we shall discuss neither their technical aspects nor the advantages or drawbacks of their propellants—major features in the progress of the *state-of-the-art*.

Our current research, naturally, leads into the very vital ballistics missiles development program. Efforts fix on the *"Atlas," "Titan,"* and the *"Thor."* The first two are designed as



Air Force missile researchers are engaged in varied propulsion experiments. High-energy solid propellant boosters that are easy to handle have high priority.

Intercontinental Ballistic Missiles (ICBM); the third is an Intermediate Range Ballistic Missile (IRBM).

Philosophically speaking—are we on the threshold of forging an "ultimate" weapon?

Committed as we are solely to defense, any potent weapon possessed by us would not ride to target on a surprise mission. But it is possible that an enemy might risk launching his own if he were convinced it would wipe out our retaliatory capabilities.

Therein lies the main reason for our feverish haste to develop a superior family of weapons. A statement made recently by U.S. Civil Defense Administrator, Val Peterson, pinpoints one overriding reason why. why.

"The age of big cities is past," Administrator Peterson said—"An H-bomb of only 10 megatons (there is talk already of 40 megatons) would destroy a modern city over an area of 50 square miles and its environs . . . If 67 U.S. cities were to be subjected to H-bomb attack (equivalent to the one which caused an island in the Pacific to disappear), 22 million people would be seriously injured; nine million would be killed."

In the light of these facts, an epochal event in weaponry might come to pass in the relatively near future—a nuclear ICBM standoff. What then?

Would a standoff prove a definite deterrent to war? Would a potential aggressor push a button sending his ICBM's screeching through the stratosphere at hypersonic speeds if he knew he was automatically pushing another button setting off the enemy's retaliatory ICBM's?

If an enemy would push his button, he would do so knowing there would be little hope he could wipe out our numerous launching sites. He would just as surely know we are prepared to retaliate.

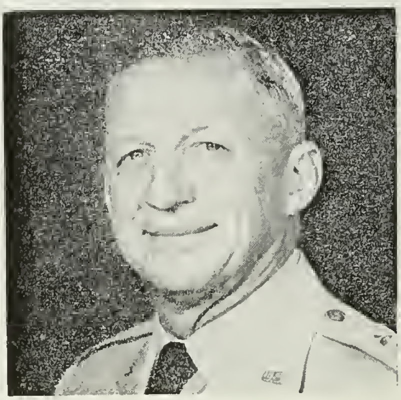
From a military standpoint, therefore, only one conclusion can be drawn from the facts presented here. Sparking World War III with the use of long-range thermo-nuclear weapons certainly would set off a chain reaction. Such rockets and missiles would then indeed be "ultimate" weapons. Ultimate that is, because the next and final one would be, as Einstein so often said, the "stone-age club."

AGAIN, philosophically speaking, can we invalidate this conclusion? We can, definitely. As military men, we do.

If "past is prologue" proves true in the case of the ICBM, we shall forever continue to seek to develop the "ultimate" weapon.

The logical step in achieving this worthwhile goal will depend entirely upon future research and development. We will always maintain a progressive attitude and look to a new frontier. This forthcoming International Geophysical Year may bring a realization of satellite launching. This within itself may open a new era of manned satellites or possibly glide rockets. With such developments, we could have stand-by forces in space guarding peace. ★

Comprehensive Testing Speeds Missile Development



By Major General Leighton I. Davis
Commander, Holloman Air Development Center, Air Research and Development Command, USAF

IT WAS my privilege several years ago to discuss with the late Dr. Robert A. Millikan the advance of modern technology. I raised the question of the relationship between theory and experiment and whether theory or experimental "gadgetry," such as electron microscopes and cyclotrons, contribute more to the growth of modern scientific knowledge. The context of his answer was that one could not advance without the other, that each was essential to progress in the sciences and that rapid progress was achieved only when theory and experiment were in proper balance—complementing and supplementing each other.

It can be said that testing bears the same relationship to engineering as experiment does to theory.

In missile engineering the relationship is even more firm, because designers and engineers invariably are required to go beyond available experimental data—to extrapolate into regimes of performance where there are no test data points to guide them.

The need for test information is taken for granted in missile work, but too often it is looked upon as verification or proof of design rather than as a partner in progress. The proper integration of testing into missile development results in rapid progress because experimental data is available when needed. If testing is treated as a "necessary evil," to follow rather than to accompany design and engineering, progress is slow and overall costs are high.

Before developing this thesis—the thesis that testing is an integral part of development and has a regenerative, beneficial effect on the progress of the project— we must look at the total pattern of development of a military weapon.

The study phase includes the definition of a military need and validation of that need by documentation. A necessary part of this phase is a formal statement of the problem and of the need for a solution; in other words, a "requirement."

The developmental phase includes design, engineering, fabrication, and many tests. Engineering testing, in contrast to proof or acceptance testing, runs throughout this phase. Designs are tested by work on computers and simulators. Engineering assumptions and compromises are tested by models and mockups. Critical components are fabricated and tested to determine performance limitations as well as weight, space, and power requirements. Vendor supplied items are checked against specifications in tests that simulate the new environment. Major components and subassemblies are tested to determine their compatibility in the system.

Flight test operations are a final part of the developmental phase. They are a continuation of the pattern of data gathering to verify or modify engineering assumptions and compromises. It is common to launch hundreds of missiles before levels of performance and reliability are achieved that justify production for inventory.

The production phase is accompanied by still more testing to check the product of production tooling and to check the latest engineering changes.

On casual consideration it might seem that a comprehensive testing program delays the date for operational use of a weapon. The time required to develop a new weapon for the military inventory is a matter of great concern to defense management. Steps have been taken to shorten the

"study" phase by speeding up the validation of the requirement, by speeding up contractor selection and contract negotiation.

The preferred way to shorten the second or developmental phase is to treat the many testing operations in this phase as opportunities to gather data faster—to feed data back into engineering so that the product will advance up the ladder of performance and reliability in a spirited progressive manner.

A poor way to attempt to shorten the development cycle is to skimp on testing—gambling on immediate large scale production. This invariably results in expensive and time consuming retooling and crash modification programs. The writer has no quarrel with production at a low rate early in the development phase, because this phase will proceed faster if more items are available for test, and because production methods and tooling must be checked before production for inventory is initiated.

To support the main thesis that testing has a beneficially regenerative influence on the progress of missile development, one must examine the timing, the data flow, and inter-relationships of design, fabrication and testing. Well planned tests—tests that quickly disclose deficiencies, tests that make data immediately available to the engineer so that he can correct a parameter or redesign a component—these steps are essential to rapid progress.

On the other hand, tests that do not include sufficient data gathering to determine the cause of malfunction, or tests that result in loss of a missile and necessitate a waiting period for the next missile—are depressing and degenerative in the sense of lowering the rate of progress towards performance and reliability. An example of the way a

USAF SM 62 SNARK takes off from Patrick AFB. Numerous test models of this missile have been launched.

sound program of testing supports and reinforces the upward trend of progress lies in component success or failure.

It is not uncommon—in fact much too frequent—that an untested item, a connector or a relay, fails during launch of a complete missile. As a result the whole project is set back—with no data on that test and a long wait for another missile—uncertainty results and requirements are generated for more tests to determine what failed. The net effect is a general depression of the rate of progress. On the other hand, comprehensive component testing aids in successful flight testing to the point of reducing the number of missiles required to determine performance and reliability.

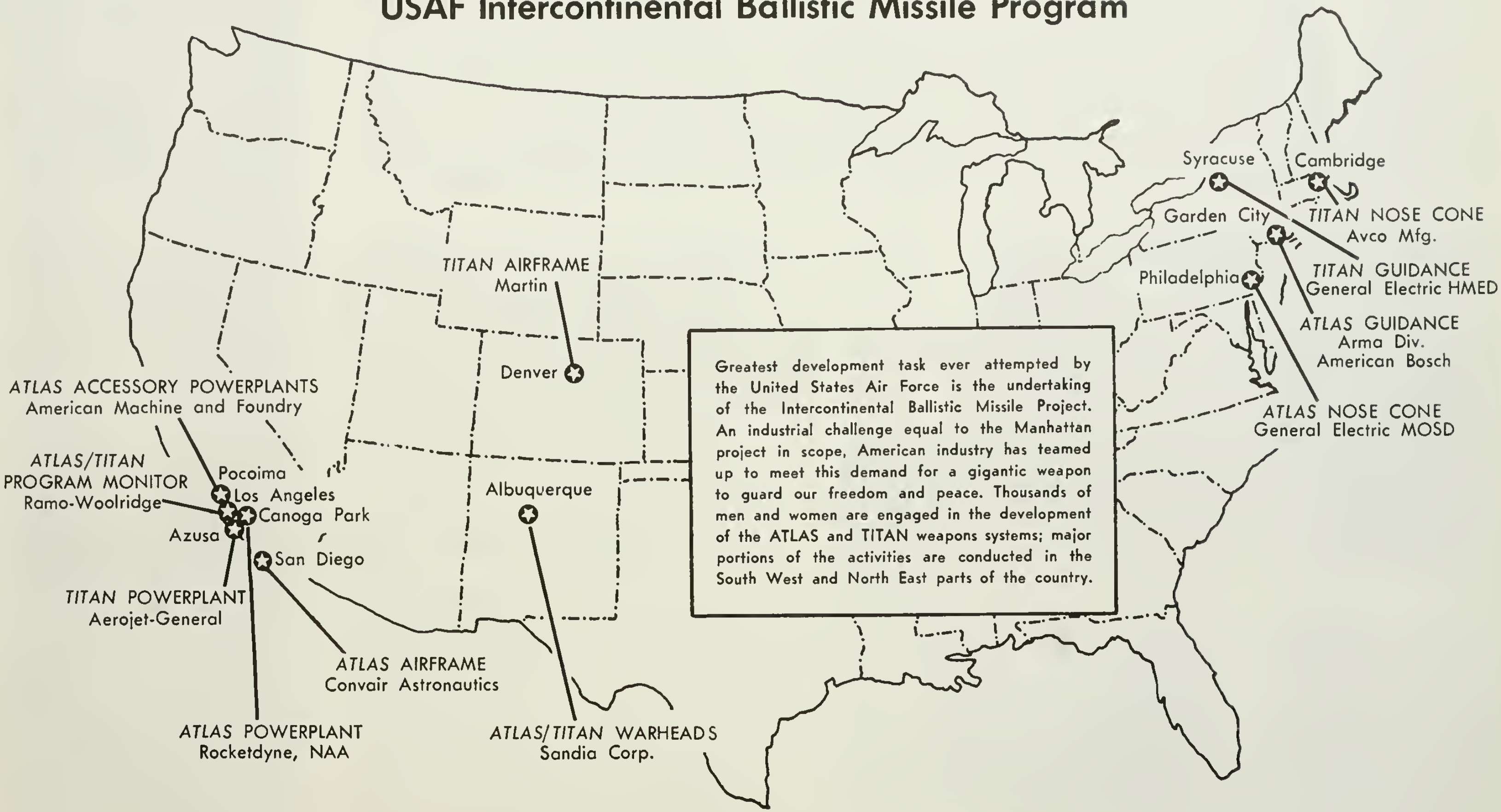
Facilities for test exert a strong influence on the rate of progress. Adequate instrumentation, sufficient telemetry equipment and channels so that ground checks can be run in parallel with flight operations, "systems designed" data gathering and data reduction equipment all speed up the development cycle by feeding test data quickly back into the engineering process.

The best proof of this thesis, that well planned and intensive testing speeds up development, lies in experience. An analysis of missile projects in the flight test phase will show a wide variation in the pattern of progress. Projects that are dragging—firing missile after missile with little increase in performance or reliability—often are plagued with component failures. These troubles could have been decreased by adequate component testing earlier in the development phase. On the other hand, some projects progress rapidly—missiles are ready on schedule, comprehensive pre-flight checks reveal few troubles—and performance and reliability are demonstrated by fewer firings than originally scheduled. Behind this success you will find extensive and careful testing, testing that goes hand in hand with design and engineering, just as experiment must accompany theory in the progress of our technology.

The big pay off is reduction in time and reduction in cost. The latter part of development, the flight testing phase, is very expensive in terms of time and money. Production tooling as well as scarce designers and engineers are standing by waiting for results. The running cost of the project may be millions of dollars per month and the missiles themselves on a per pound cost are more dear than gold and diamonds. Rapid progress towards goals of performance and reliability decreases the running time of the project and saves missiles in the most critical and expensive phase of the total weapon development. ★

Lockheed F-94 carrying full-size missile in its nose (circled) is used by Air Force as flying test bed for checking out missile guidance and telemetering gear. This approach saves money. Other Air Force missiles are designed to return to base and land after test flight.

USAF Intercontinental Ballistic Missile Program



Greatest development task ever attempted by the United States Air Force is the undertaking of the Intercontinental Ballistic Missile Project. An industrial challenge equal to the Manhattan project in scope, American industry has teamed up to meet this demand for a gigantic weapon to guard our freedom and peace. Thousands of men and women are engaged in the development of the ATLAS and TITAN weapons systems; major portions of the activities are conducted in the South West and North East parts of the country.

A New Approach to Space Flight

Should the space flight challenge be attacked on the basis of our missile and rocket experience? Or should we attempt a different approach?

By Colonel William O. Davis
Office of Scientific Research, Air Research and Development Command

THE most popular approach to the conquest of space up to the present time has been the ballistic type vehicle, high accelerations, vertical takeoffs and chemical fuels. In other words, we are asking ourselves, "In what way may we extrapolate the techniques of the guided missile to manned spaceflight, how can we use the rocket to put a man in space?"

This perhaps is not the best approach today. Instead of continuing to extrapolate our past techniques into the future, let us stop and take stock—see what capabilities do exist for manned spaceflight and whether or not we can meet them with the techniques available to us. Let us forget for the moment we ever heard of the rocket and the guided missile. Let us assume that we will start from scratch with the science that is available to us and a knowledge of our objectives and design a spaceflight system from here.

In trying to decide what the requirement must be for a usable space-flight vehicle, one can take many approaches. The list below is only one possible such list.

1.) High Probability of Personnel Recovery.

2.) High Probability of Equipment Recovery.

3.) High Probability of Mission Success.

4.) Human compatibility with the system.

- (a) Low but no zero acceleration.
- (b) Tolerable temperature limits.
- (c) Short flight times.
- (d) Reasonable re-entry profile.

5.) Performs Function Compatible With Cost. Let us discuss each of these requirements briefly.

High probability of personnel recovery implies first of all adequate protection against the various environmental hazards of space; secondly, however, it implies that a power failure at any phase of the mission must not result in a loss of control and ability of the vehicle to fly. This, of course, is a very rigorous requirement and suggests either multiple motors—the failure of any one of which will not cause loss of control, a propulsion system which is inherently incapable of failure, or a flight condition where power-off control is feasible until emergency escape can be made.

The second requirement, high probability of equipment recovery, implies all the foregoing and in addition requires that the spaceship be capable of being landed with high reliability in the event of complete power failure. It also means that if staging is used each of the separate stages must be recoverable and re-usable. Finally, it points to the desirability of a single stage vehicle which eliminates the necessity for staging.

High probability of mission success implies in addition to all the foregoing that the entire system be made as completely reliable as possible and that the necessary

maneuvers to complete the mission be possible and easily performed, without serious risk to personnel and equipment.

We come now to the question of human compatibility with the spaceflight system.

(a) Low but not zero acceleration: It is clear that a necessity for high accelerations will greatly limit the flexibility of space travel and in particular will require that only the most physically fit may possibly employ this form of transportation.

Secondly, high accelerations will produce a much greater stress on all parts of the vehicle thus increasing the probability of failure of the components and of the system as a whole. Thus, a desirable objective is to develop a ship which has the lowest possible acceleration compatible with fuel economy and mission to be performed.

Human Survival

At the same time even though experience may demonstrate that man can survive and even adapt himself completely to life under conditions of zero gravity, such conditions certainly will add to the difficulty of operation in space and should be avoided if at all possible. Zero gravity may be avoided either by the artificial rotation of the vehicle to substitute centrifugal force for gravity, or perhaps by the employment of a method of propulsion yielding low acceleration.

(b) Tolerable temperature limits: Any propulsion system will produce some heat. A space vehicle within sight of the sun also will be receiving heat from the solar radiation. A major problem on a vehicle well may become that of maintaining a livable temperature while absorbing heat from the propulsion system or auxiliary power system and adding it to the heat already being received from the sun.

For example, the mean temperature of a space vehicle at the same distance from the sun as the earth will, of course, be essentially the same as that of the earth—approximately 68°F. Clearly an average temperature much higher than this is undesirable, so that transfer of heat to the vehicle by the propulsion system or auxiliary power system should be minimized. Where possible the heat from the propulsion system should be used for auxiliary power, so that by doing work the total energy release to the vehicle in the form of heat may be kept as low as possible.

Finally, the man himself must be a part of this thermodynamic system and his products and his heat must fit into the system in such a way as to insure maximum survival probability and maximum efficiency. One more factor is important in connection with this requirement. The thermodynamic cycle of man and machine must be studied carefully because in this application it is clear that we wish to consume energy and conserve mass.

(c) Short flight times: Under most early approaches to flight between two planets the minimum energy orbit has been suggested. This, in general, requires a long time and may well involve serious personnel and logistic problems.

On the other hand a system of spaceflight in which the vehicle could be accelerated even though at a reduced rate for an indefinite period of time would permit much more rapid travel between two planets and, therefore, noticeably reduce personnel and logistic problems. This objective, consistent with other technical problems involved, is highly desirable.

(d) Reasonable re-entry profile: It stands to reason that the return into the atmosphere of earth and landing on the earth should follow a profile which does not impose excessive thermal loads or accelerations upon the human passengers of the vehicle.

The requirement that the space vehicle must perform a function compatible with its cost implies, I believe, a very thorough study of the military and civilian utilization of space travel. At the present time, relatively little consideration has been given to this subject.

In the early days of military aviation, shortly after the Wright Brothers had made the first manned flight, the military view was limited to that of employing the aircraft for observation purposes. The development of the modern philosophy of air power took many years. Since spacecraft will inevitably be much more expensive than the early aircraft, it appears essential that this phase be undertaken prior to the development of vehicles for manned spaceflight.

Now is the time to undertake extensive studies of the strategic and tactical employment of spaceflight for military purposes. At the same time, as has been the case throughout history, there will inevitably be important civilian and commercial applications of flight in this new environment, and it goes without question that thought should be given to this subject.

In considering these applications attention should be given not

With a new approach to basic problems man may still succeed in attempt to conquer space

to the difficulties of achieving spaceflight with today's techniques, but to the assumption that an idealized form of spaceflight can be developed in which many of the objections which face us today will no longer be present. In other words, one should assume that spacecraft may be flown with no more difficulty than that encountered today in the operation of aircraft for commercial purposes.

Landing On Other Planets

In order to perform a useful function for either military or commercial purposes, it would appear that a capability to land on other planets is highly desirable. This problem is undoubtedly a difficult one and is a sensitive function of the amount of atmosphere possessed by other planets, the type of propulsion system and the method of control. Achievement of this capability might well require the presence of more than one propulsion system or at least a propulsion system which might be used in two or more modes.

Since it cannot be expected that prepared landing surfaces will be available on the surface of other planets, it is clear that this vehicle must be able to land under conditions of rugged terrain. Particularly from the point of view of military operations, but later for commercial operations, a certain amount of maneuverability is desirable.

Consider, for example, a space station or other observation platform in an orbit about the earth. Such a station might in one application be used for the purpose of military reconnaissance or observation of the enemy by photographic, telescopic and radar means. Such a vehicle would be extremely vulnerable if it were committed to a completely predictable orbit. It would be necessary only to compute the exact position which the satellite would occupy at a given time in order to direct a counter missile against this target. Thus, in this particular application the ability to maneuver, to change velocity, to change position, to vary the orbit becomes important.

If indeed space is to be the next major military environment, it is clear that ultimately we may expect the possibility of combat operations in space. Under these conditions it is certain that maneuverability will be required.

Both the planetary landing capability and the ability to maneuver imply that this vehicle must be able to carry a large fuel reserve for sustained operations in space and a safe return of personnel and equipment to base. Fuel reserves should be at least comparable to those used in present day military aircraft and considering the nature of the environment a factor as high as 2 would not be excessive.

Finally, there is the matter of economy to discuss. If, as in the case of the atomic bomb, an enormous strategic advantage should be gained from the development of a space vehicle then certainly this would be worth a major national effort regardless of cost.

However, if we are to consider spaceflight as a routine future military possibility, and in particular, if we are to consider it as a commercial possibility, then the matter of economy becomes of much greater concern. It is, of course, unlikely that any such system will be developed cheaply, but if at the completion of a development program, future units can be built at relatively low cost, then this type of transportation may in time become quite feasible on a reasonably routine basis.

Let us, therefore, stipulate that for routine space operations it is desirable that unit cost of production vehicles be relatively low including the cost of fuel and other auxiliary equipment. Secondly, it will be extremely uneconomical to attempt to maintain military operations on a continuing basis with vehicles which can be used only once. It is necessary that the ultimate vehicle for spaceflight involve neither expendable vehicles nor expendable stages or other components.

Economical Aspects

All major portions of the equipment should be both reclaimable and reusable in order for this venture to be economically feasible.

Regarding the all-important question of fuel and propulsion as it affects economy of operation, it appears obvious that the most desirable system will be one incorporating a low mass ratio.

Certainly mass ratios of one hundred to a thousand or higher are completely impractical in terms of the economical transportation of payloads between the planets on a routine basis. Thus, the ultimate propulsion system should be one which provides for as low a mass ratio as possible. This means systems involving high exhaust velocities or linear systems of propulsion which do not incorporate the conversion of energy to thrust by means of heat. Nuclear propulsion, if proved feasible, would meet this requirement. Many other possibilities have been suggested—for example, ion propulsion.

If space travel is to become a routine operation between planets it is clear that the fuel for the vehicles should be relatively plentiful in the solar system and in fact the optimum situation would be one in which the fuel was available on any planet and could be refined with equipment transportable within the space vehicle itself. Hydrogen or any form thereof would meet this criterion and there are other possibilities.

Certainly this set of requirements sounds very stringent if not impossible to achieve, at least until some far future time. But if history follows its usual course, we may logically expect a capability of this type to develop rather unexpectedly. As in the case of the atom bomb. Since we cannot afford to follow all possible routes to the future the most likely avenues of research must be pursued at this time.

It seems clear that propulsion is the key to the whole problem. A propulsion system which would provide continuous though low thrust for an indefinite period of time would provide the answer to many of the problems that have been raised. If this type of propulsion system were available today, it certainly would be possible to think in terms of a workable space vehicle.

In my opinion, the way to manned spaceflight would then be open almost immediately, provided we had the auxiliary problems solved in the meantime. Although it might well take fifty years to solve the engineering problems of putting a man in space with current missile concepts, it is likely that the utilization of new concepts will achieve the same results sooner. It is easier to climb over a stone wall than to beat our way through with a jack hammer. ★

Defense Secretary Wilson

Wilson's Missile Order—Detailed Text

Because of its potential vital bearing on the rate of development of U.S. missile progress and on the outcome of the West's battle with Russia for air supremacy, m/r herewith reprints the missile sections of The Secretary of Defense's November 26 Memorandum for Members of the Armed Forces Policy Council.

MEMORANDUM FOR: Members of the Armed Forces Policy Council.

SUBJECT: Clarification of Roles and Missions to Improve the Effectiveness of Operation of the Department of Defense.

Important changes in organization and in roles and missions are not easily decided upon or effected. It is not as though we were starting fresh with a clean sheet of paper, so to speak, or could set up a theoretically perfect organization and division of responsibilities between the Military Departments. Assignment of responsibilities must continue to recognize the precedents of the past and the availability of men and facilities for carrying out assigned missions. Problems of this nature would be easier to solve if there were always complete unanimity of opinion among all responsible executives of the Defense Department, both military and civilian. The very nature of the problems, however, and the varying background and experience of the individuals serving in responsible positions make some differences of opinion normal and to be expected.

In spite of the differences of opinion which may exist, there are times when conditions require that changes should be made in administrative responsibilities and at such times decisions are mandatory. That is the situation now.

The National Security Act of 1947 states:

"Declaration of Policy

"Sec. 2. In enacting this legislation, it is the intent of Congress to provide a comprehensive program for the future security of the United States; to provide for the establishment of integrated policies and procedures for the departments, agencies, and functions of the Government relating to the national security; to provide three military departments, separately administered, for the operation and administration of the Army, the Navy (including naval aviation and the United States Marine Corps), and the Air Force, with their assigned combat and service components; to provide for their authoritative coordination and unified direction under civilian-control of the Secretary of Defense but not to merge them; to provide for the effective strategic direction of the armed forces and for their operation under unified control and for their integration into an efficient team of land, naval and air forces but not to establish a single Chief of Staff over the armed forces nor an armed forces general staff (but this is not to be interpreted as applying to the Joint Chiefs of Staff or Joint Staff)."

Nine years of experience operating under the National Security Act of 1947, as amended, have proved the soundness of this comprehensive program for national security.

The statement of roles and missions recommended by the Joint Chiefs of Staff at Key West and Newport and approved by Secretary of Defense James Forrestal and as modified in 1953, have also proved to be sound and effectively to implement the intent of Congress as expressed in the National Security Act.

No basic changes in the present roles and missions of the armed services are necessary but the development of new weapons and of new strategic concepts, together with the nine years' operating experience by the Department of Defense have pointed up the need for some clarification and clearer interpretation of the roles and missions of the armed services. We have recognized the need for a review of these matters and from time to time certain steps have been taken and we are now taking others to improve the effectiveness of our overall military establishment, to avoid unnecessary duplication of activities and functions, and to utilize most effectively the funds made available by the people through Congress.

I would like to point out that clarification and interpretation of roles and missions does not in itself predetermine the weapons to be used by each of the armed services and their numbers, nor the numbers of men to be trained in various fields. It should be clearly understood that the approval of roles and missions of the armed services for guidance in peacetime does not predetermine the weapons or forces which a commander in the field would be permitted to use in the event of war. Also, the development of a weapon by a particular military department does not in itself predetermine its use. Such determinations rest with the Secretary of Defense after considering the recommendations of the Joint Chiefs of Staff and the Secretaries of the Military Departments.

The recent clarification of command responsibilities for field commanders should be most helpful in determining weapons and forces to be employed in various missions and should assist the Joint Chiefs of Staff in making recommendations in this regard to the Secretary of Defense, in order to determine approved requirements for each of the armed services.

We have recently reviewed five important problem areas which need to be cleared up. The recommendations of the Joint Chiefs of Staff in regard to these matters have been carefully considered and their differences of opinion carefully weighed. In addition, I have given consideration to the opinions in these areas of responsible officials, both military and civilian, in the Office of the Secretary of Defense. These matters are being resolved as follows:

(Parts 1 and 2 on manned aircraft omitted)

3. *Air Defense.*

Consideration has been given to distinguishing between Air Force and army responsibility for surface-to-air guided missile systems for defense of the Continental United States on the basis of area defense and point defense, as well as the criterion of an arbitrary range limitation.

Area and point defense systems cannot be defined with precision. Area defense involves the concept of locating defense units to intercept enemy attacks remote from and without reference to individual vital installations, industrial complexes or population centers. For such a de-

fense system to be effective, extensive information gathering networks such as the Semi-automatic ground environment (SAGE) system are required to trace continuously the enemy attack and transmit and present the data in usable form for guiding the defense weapons to counter the attack. As applied to surface-to-air missiles, this means that area defense missiles, because of their more widespread sitings, will normally receive their guidance information from the network system rather than from acquisition and tracking radars located in the vicinity of the missile launching site.

Point defense has as its purpose the defense of specified geographical areas, cities and vital installations. One distinguishing feature of point defense missiles is that their guidance information is received from radars located near the launching sites.

The present state of the art justifies development of point defense surface-to-air missile systems for use against air targets at expected altitudes out to a horizontal range of the order of 100 nautical miles.

It must be clearly understood that the Commander-in-Chief, Continental Air Defense Command, who has been given the responsibility for the Air Defense of the Continental United States, Alaska, and the United States area of responsibility in the North East, also has the authority and duty for stating his operational need for new or improved weapon systems and for recommending to the Joint Chiefs of Staff all new installations of any type. Therefore, no Service shall unilaterally plan for additional missile installations of either category (point or area defense) in support of CINCONAD's responsibilities until and unless they have been recommended by CINCONAD to the Joint Chiefs of Staff, and approved by that body.

In conformance with the above:

a. The Army is assigned responsibility for the development, procurement and manning of land-base surface-to-air missile systems for point defense. Currently, missile systems in the point defense category are the NIKE I, NIKE B, and land-based TALOS.

b. The Air Force is assigned responsibility for the development, procurement and manning of land-based surface-to-air missile systems for area defense. Currently, the missile system in the area defense category is the BOMARC.

c. The Navy, in close coordination with the Army and Air Force, is assigned responsibility for the development, procurement and employment of ship-based air defense weapons systems for the accomplishment of its assigned functions.

d. The Marine Corps is authorized to adapt to its organic use, such surface-to-air weapons systems developed by the other Services as may be required for the accomplishment of its assigned functions.

e. In overseas areas, the U.S. theater commander should normally assign responsibility for air defense to an air component commander, with appropriate participation by other components. Under this arrangement, Army units in combat zone should continue to be responsible for their own local defense, employing organic means. Other Army air defense units should carry out point defense missions under the air component commander. Air Force units should carry out the area defense missions. Special emphasis should be given to simplicity, flexibility and mobility of weapon systems employed in air defense in overseas areas. Navy forces should continue to be responsible for their own air defense at sea, employing organic means. As approved by the theater commander, the air component commander should establish such procedures for coordinating Army, Navy, and Air Force air defense forces as may be required to carry out his responsibilities, and, in addition, should establish such detailed procedures as are necessary for proper coordination with national air defense commanders of allied countries.

4. *Air Force Tactical Support of the Army.*

The Army will continue its development of surface-to-surface missiles for close support of Army field operations with the following limitations:

a. That such missiles be designed and programmed for use against tactical targets within zone of operations, defined as extending not more than 100 miles beyond the front lines. As such missiles would presumably be deployed within the combat zone normally extending back of the front lines about 100 miles, this places a range limitation of about 200 miles on the design criteria for such weapons.

b. That the tactical air support functions beyond those that can be provided by Army surface-to-surface missiles as above defined remain the responsibility of the Air Force.

It is evident that the tactical air forces programmed for Army support should be reconsidered and the Joint Chiefs of Staff have been requested to furnish me with their recommendations for specific adjustments as to the number and types of planned Army guided missile and unguided rocket units and with the number of Air Force tactical wings which may be eliminated as a result of these decisions.

In preparing these recommendations, the development of balanced and interrelated Army and Air Force tactical support forces for the accomplishment of overall U.S. national security objectives must be considered, rather than the development of completely independent Army and Air Force forces to accomplish tactical support tasks. In developing force recommendations in this area, as well as for other U.S. Military forces, it should be recognized that all operations in which our forces will be employed will be conducted under the command of the designated commanders who will have the necessary forces assigned to them for the conduct of their missions by higher authority.

5. *Intermediate Range Ballistic Missile (IRBM).*

In regard to the Intermediate Range Ballistic Missiles:

a. Operational employment of the land-based Intermediate Range Ballistic Missile system will be the sole responsibility of the U.S. Air Force.

b. Operational employment of the ship-based Intermediate Range Ballistic Missile system will be the sole responsibility of the U.S. Navy.

c. The U.S. Army will not plan at this time for the operational employment of the Intermediate Range Ballistic Missile or for any other missiles with ranges beyond 200 miles. This does not, however, prohibit the Army from making limited feasibility studies in this area.

(The Intercontinental Ballistic Missile has previously been assigned for operational employment to the U.S. Air Force.)

There are a number of other matters relating to research and development of particular weapons that will affect the choice of weapons to be used for various missions in the armed services. These choices can only be made after a careful technical review of the capabilities of the various weapons under development. I refer particularly to weapons systems such as the NIKE and TALOS and the multiple approach (JUPITER-THOR) to developments such as the Intermediate Range Ballistic Missile. This memorandum does not attempt to answer those questions which can only be decided after studies now in progress are completed, and should not be so interpreted.

In the meantime, these competing weapons systems will be continued with support from Fiscal Year '57 funds until the completion of the technical evaluation referred to above. Budget support in Fiscal Year '58 for the land-based TALOS, as required, will be provided by the U.S. Army. Budget support in Fiscal Year '58 for the land-based Intermediate Range Ballistic Missile Program, as required, will be provided by the U.S. Air Force.

In view of the great interest in these matters in the Congress, copies of this memorandum are being sent to the appropriate Congressional Committees. In addition, in order that there can be full understanding of these decisions within the Military Departments and by the public, copies of this memorandum are being made available to the press.

C. E. WILSON

Washington Spotlight

By Henry T. Simmons

The Air Force has started a detailed technical evaluation of *Jupiter* mid-range ballistic missile to determine how much of the former Army project should be continued to supplement its own work on the *Thor*. Recommendations are to be ready by Feb. 1. Big problem is how to handle the development of the Navy's Fleet Ballistic Missile if the *Jupiter* program is sharply cut back. Some airmen suggest the sailors could get along with an 800-mile weapon rather than the 1500-mile *Jupiter* in which they were participating with the Army.

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The USAF *Thor* intermediate range ballistic missile has already been shipped to Patrick AFB, Fla., and it is said first prototype will be fired this month. Douglas engineers have reportedly made phenomenal progress on the bird.

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Lockheed is begging the Air Force to let it release pictures and further news of its three-stage X-17 research rocket, designed to gather information on ICBM warhead reentry problems. (M&R, Nov., 1956, p. 43). Unclassified models of the *Sergeant-Recruit* rocket combination have been distributed.

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The Air Force is pushing research work on a workable missile defense system for bombers, but it hasn't found the answer yet. Biggest headache is the design of a finned missile which can be launched *across* the bomber's airstream without being thrown completely off course.

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Relaxation of the Defense Department's policy for dispersal of key military production facilities seems to be under way. Boeing, for example, recently took an option to buy a Ford plant at Richmond, Calif., for assembly of the USAF *Bomarc* interceptor missile. If it goes ahead with the purchase, it will mean that the hard-driving dispersal policy of former USAF Secretary Harold Talbott is virtually dead.

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Air Force intelligence has learned that the Russians have developed a rocket engine of 120 metric tons thrust—more than 264,000 pounds. Although extremely large solid propellant engines have been tested in the U.S., the largest liquid propellant engine shown publicly is the 140,000-pound North American booster for the *Navaho*. Much larger engines are under development for the *Atlas-Titan* ICBM program, however.

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Top Pentagon officials are not entirely satisfied with the progress of the Air Force missile program, noting that the airmen have only two fully operational missiles today, despite years of development labor, while the Army and Navy have four or five each. One official blames the slow progress on Air Force reluctance to top off questionable projects.

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The stretch-outs ordered last month by the Air Force in the WS-110A chemical bomber and WS-125A nuclear bomber projects may not be enough to satisfy Pentagon budgeteers. Look for a further slowdown—particularly in the nuclear bomber—to make more funds available for the big ballistic missiles.

Aerophysics

By Seabrook Hull

The *Vanguard* project constitutes man's first venture in the fourth environment—space. It is a technological accomplishment of profound historical significance. However, in the quiet background, projects are already in the hardware stage that will take living men as well as black boxes beyond atmosphere's outer limits.

One is the AF's North American X-15. It requires not only the full abilities of near-escape, but those of a safe reentry as well. Unlike the ICBM which need only remain lethal for a few seconds, both the X-15 and its pilot must return to fly again.

Considered test vehicles for inhabited space bombers, manned satellites, etc.—X-15's A, B, and C will reportedly explore 3000 mph, 50 mi. up; 4500 mph, 100 mi. up; and 6000 mph and over, 150 mi. up and out.

The range of operating conditions of the X-15—from near-space flight to the sea-level environment of approach and landing—is unprecedented and necessitates virtually an entire new vehicle system. Throughout reentry and descent, its speed (controlled by glide angle) must be slow enough to maintain laminar flow in the boundary layer and fast enough to maintain control effectiveness. Too fast, and the resulting turbulent boundary layer will transfer heat to skin at a destructive rate. Too slow, and the loss of control will be catastrophic.

The speed band between too fast and too slow is extremely narrow and varies critically with altitude. The X-15's piloting system will be of the command variety, automatic and more sensitive than the human touch. Measurement of flight conditions—altitude, speed, rate of descent and climb, pitch, roll and yaw—requires new techniques. A thin probe would melt. A stainless steel ball with static ports may be used instead. Aneroid devices are useless. And in 100 per cent dissociated air, radio may be unreliable.

Vanguard and its successors will explore the massive high-energy spectrometer that is space, and give some indication of effect on pilot, plane and astrionics gear. As soon as these results start coming back, X-15's system will be finalized and should fly in two years.

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Dissociation becomes a vital science in itself. It is the basis for "free radical" fuels; it controls heating rates in hypersonic flight; and (the latest) it cuts combustion efficiency in low-pressure rocket engines. A little light reading on the subject will help anyone concerned with the coming ages of flight.

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Research shows that the laminar flow equilibrium temperature at Mach 8.0, altitude 150,000 ft. of a point on a wing 10 ft. back from the leading edge is 1000°F, assuming skin has 0.85 emissivity; and that of the leading edge itself is 4500°F, against a stagnation temperature of 6500°F.

THE NAVAHO CHALLENGE

By Henry T. Simmons

MANY companies have made their fortunes on a single fruitful idea but few have learned how to assure the continuous production of significant ideas and their profitable exploitation.

Among those few, the name of North American Aviation, Inc., must surely be included. Its formula: Tackle a project so challenging from a technological standpoint that the answers, when obtained, must necessarily open broad and profitable new avenues in the business and industrial world.

The challenging project in North American's case is the SM-64 *Navaho* intercontinental missile. It was initiated by the U.S. Air Force in 1950 and has been under high pressure development ever since.

Little has been said officially of the *Navaho*. Pentagon officials describe it in their speeches as an air-breathing surface-to-surface missile with a range of about 5,000 miles. Beyond that, they hold their silence.

But a considerable number of additional details have been unofficially but reliably attributed to the North American bird. It is said to be capable of speeds of about Mach 2.5 at altitudes up to 75,000 feet. Its weight is probably in excess of 50 tons. It employs some radical airframe innovations, included a canard stabilizer just behind the nose.

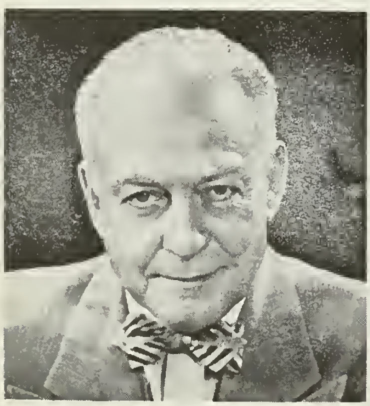
Power for the *Navaho* is supplied by two different engines. For sustained flight, it is said to use two huge Curtiss-Wright ramjet engines. And to achieve the speeds necessary to generate sufficient ram air pressure to permit the C-W engines to operate, the *Navaho* uses a large North American liquid propellant rocket engine with a designed thrust of 140,000 pounds.

An indication of the present status of the program is the fact that flight testing of the North American X-10 test vehicle is now nearing completion at the Air Force Missile Test Center, Patrick AFB, Fla. Although the firing range extends 5,000 miles from Florida to the Ascension Islands in the South Atlantic, only a fraction of that distance is now in use for the X-10 program.

The test vehicle, which is equipped with retractable landing gear, is apparently aerodynamically similar to the *Navaho* itself. Power is supplied by a pair of turbojet engines, variously reported as Westinghouse J40's and Pratt & Whitney J57's. The X-10 is used to check out advanced designs, electronics systems and flight characteristics.

With the end of the X-10 test program in sight, North American is ready to move into the final and most difficult stage of development—that of test firing the genuine article. Both range and missile instrumentation have been designed to gather performance data along the entire course of the sprawling range, and it is expected that this final stage will begin shortly.

These sketchy details illustrate something of the magnitude of North American's task in designing and developing the *Navaho*. Probably one of the most acute problems is that of aerodynamic heating. At velocities of Mach 2, for example,



J. H. Kindelberger, Board Chairman, North American Aviation, Inc.

L. L. Waite, Vice-President, North American Aviation, Inc.

Joseph G. Beerer, General Manager, Missile Development Division.

Samuel K. Hoffman, General Manager, Rocketdyne Division.

Dale D. Myers, Chief Engineer, Missile Development Division.

T. F. Dixon, Chief Engineer, Rocketdyne Division.

surface heating as great as 300 degrees F. may be expected, while Mach 3 will produce temperatures of about 660 degrees F.

To be sure, missile test vehicles have already achieved speeds of Mach 10 and above, but these were rocket-powered ballistic devices with very short flight durations. In the case of the *Navaho*, which will maintain velocities of 1650 mph to 2000 mph for a period of several hours, the problem is to lick the effects of *sustained* intense heat.

From a structural standpoint, the heat problem seems to be well in hand. In that area, the principal headaches are heat-induced expansion and shrinkage, further complicated by stress and vibration. While aluminum alloys and steels remain useful for certain applications in the *Navaho*, very extensive reliance on titanium alloys proved necessary to meet new strength-to-weight requirements. Titanium is much stronger than aluminum, possessing the strength of some carbon steels, but at the same time it is 40% lighter than steel.

Thermal Problems

One of the knottiest heat problems in the *Navaho* has to do with fuels and hydraulic fluids. How do you prevent the liquids from boiling or detonating at the enormous temperatures to which the skin will be subjected? North American engineers have sought a variety of answers, including ways to keep liquids from boiling, development of fuels requiring no refrigeration and methods of cooling fuels without greatly increasing weight. Just how they have resolved the difficulty has not been suggested.

Still other new problems were encountered in designing control surfaces capable of handling mammoth air loads. One of the *Navaho's* control planes is the size of a drafting table, yet it is sturdy enough to bear the weight of six automobiles.

North American engineers ready a model, possibly suggestive of the NAVAHO, for wind-tunnel tests. Note the extreme fineness ratio, the delta airfoil on the aft section and the small canard stabilizer close to the nose.

Vibration and flutter are particularly acute problems for all missiles, including the *Navaho*. Notes one expert:

"Vibration in the wrong place can cause disaster. All missile systems and equipment are sensitive to some form of vibration. Suppose, for instance, that automatic control equipment is improperly mounted or located. It may send the wrong set of signals to the control surfaces, which would amplify the vibrations. Control surfaces could be ripped off and the vehicle entirely destroyed."

Fabrication of one large aluminum section for the *Navaho* also involved peculiar problems. There was no tooling large enough to hold certain important structural units, nor was there a proper fusion welding machine available. Engineers of NAA's Missile Development Division coordinated the construction of one of the largest jigs in the company's history to hold the aluminum pieces tightly against one another. They also adapted a fusion arc welder bathed in a stream of inert gas which is capable of joining seams at the rate of 20 inches a minute.

New Industrial Know-How

As a result of its weapon system responsibility for the *Navaho*, North American has encountered virtually every problem facing missile engineers today. Its response to these challenging difficulties has resulted in the development of valuable new industrial processes and know-how,

and has opened important new avenues of future growth.

During the brief period the *Navaho* has been under development, for example, three new divisions have been split off from the parent Missile Systems Division. All were organized last year.

Most important is Rocketdyne, which came into being as a result of NAA's development of large, high-powered liquid propellant rocket engines not only for its own requirements but for other highly important missile projects. With headquarters at Canoga Park, Calif., the division presently has 8600 employes and expects to add another 3000 in 1957. It now has orders to supply rocket engines for all but one of the large rocket-powered missiles now under development in the U.S. They include the *Navaho*, the Army Ordnance *Redstone*, the Convair *Atlas*, Martin *Titan*, and the Douglas *Thor*. The exception is the Army-Navy *Jupiter* project.

Recently described by NAA Board Chairman J. H. Kindelberger as "one of the brightest spots in the North American picture," Rocketdyne is presently the leader in U.S. rocket propulsion technology by virtue of its long head start in the field. Although other companies are now beginning to press it, Rocketdyne remains "the only company able to deliver proven engines of very high power," Kindelberger declared.

In addition to its Canoga Park facility, where Rocketdyne has more than 450,000 square feet of new engineering and administrative space in operation or under construction, the division operates two other important facilities. These are the Propulsion Field Laboratory, located in a 1600-acre section of the Santa Susana Mountains north of Los Angeles, and an engine plant at Neosho, Mo.

The Santa Susana facility is used to test very large rocket engines, turbopumps and other components; for this purpose, more than a dozen test stands capable of withstanding enormous thrusts during firing runs have been installed. The Neosho facility was originally scheduled to be operated by Aerojet-General Corp., but the USAF abruptly switched it to Rocketdyne.

Two other NAA divisions which owe their origin to early work on the *Navaho* and other missiles are Atomics International and Autonetics. The former was created to exploit peacetime uses of atomic energy for generation of electric power, following NAA's early studies of the feasibility of nuclear energy for propulsion of missiles and aircraft. Its two principal projects are a sodium reactor experiment at Santa Susana and an organic moderated reactor in Idaho, both under construction for the Atomic Energy Commission.

Autonetics was organized to exploit advances achieved in the development of automatic navigation and control devices required for missiles and piloted aircraft. One of its most promising fields is that of inertial navigation for guided missiles. Although its work is still largely in the research and development stage, Kindelberger said, "it is hoped that several of the good products emerging now from development will bring large production orders."

North American has also developed a number of important industrial processes as a direct outgrowth

of the *Navaho* program. One of these is the CHEM-MILL process, patented by NAA and licensed throughout the aircraft industry by Turco Products, Inc., Los Angeles. It is an etching process which cuts away unwanted material by chemical rather than machining methods.

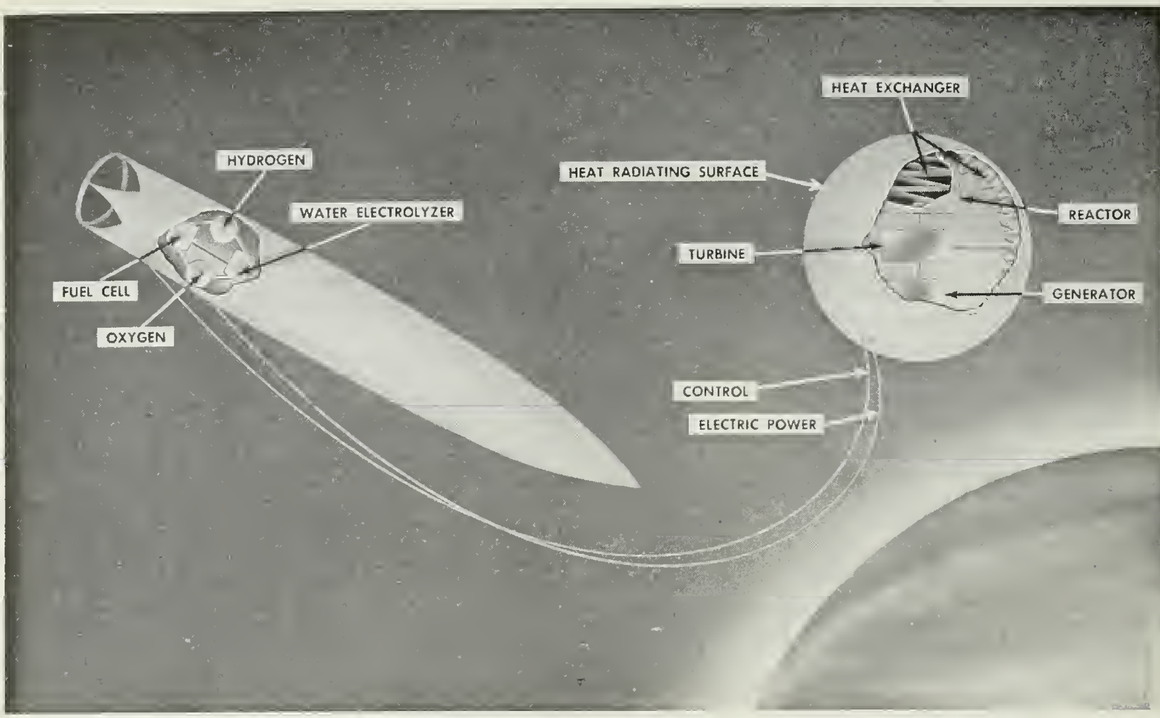
Development of this process came about when an NAA research unit found there was simply no other means of forming a particular missile section. Its value lies in the fact that it can carve many complex single-piece sections out of metal which previously had to be assembled from as many as 20 bits and pieces. Furthermore, the new sections are lighter from the assembled sections.

Navaho Test Flight

First Navaho test flight from Patrick AFB is being planned. North American engineers and Air Force officials are believed to have scheduled the flight for late this year. Although the ARDC missile range extends 5,000 miles into South Atlantic to Ascension Island first flight is not expected to cover this distance. The huge missile—first true intercontinental U.S. guided weapon—will use conventional turbojet engines in addition to ramjets. Operational model is designed as liquid rocket/ramjet vehicle. Navaho is scheduled to become U.S. Air Force's first long-range missile—until the Atlas and Titan ICBMs become operational.

Despite North American's success in converting the problems of missile engineering into new and profitable lines of activity, the real significance of its *Navaho* effort is the fact that this weapon will probably be the first full-fledged operational intercontinental missile to go into the Air Force inventory.

Although the Northrop *Snark* turbojet-powered intercontinental missile could probably go into operational use any time the Air Force desired, it is likely that the Air Force will postpone procurement of such a weapon until the *Navaho* is available. No less an official than Pentagon Missile Czar Eger V. Murphree supports this view, noting that the *Navaho* represents a bolder attack on the state of its art than its Northrop rival. ★



Artists' conception of how a satellite vehicle—manned or unmanned—may use atomic power supply. Power unit may follow the satellite at some distance for radioactive protection.

Power Sources for Space Flight

By Dr. S. Fred Singer
Professor, Physics Department
University of Maryland

NEXT to rocket propulsion, electric power is the most important ingredient of space flight whether unmanned or manned. Guiding equipment, computers, electronic circuits, transmitters and receivers, all require electric power; and human occupation increases these requirements markedly.

No wonder then that in the design of space vehicles the provision of electric power plays such an important role. There are two general methods for solving this problem: one can either take the power along or, one can pick it up along the way. Chemical batteries, radioactive and nuclear power supplies belong to the first category.

In the second category we must make use of energy sources which exist in the universe, our most convenient source being the sun. Among these four methods, namely chemical, radioactive, nuclear and solar, the choice generally can be made in terms of the overall degree of complication of the satellite, the amounts of power required, the importance of radiation hazard, and similar factors. For example, one would not put a nuclear power supply in a minimum satellite whose total requirements are in the order of a few watts of electric power. Similarly, a chemical battery by itself could not economically furnish power for a large space vehicle.

Table I

Energy Output of a Power Supply Divided by its Weight

	Watt-hour/lb	Power Range (Watts)
Dry battery	14	< 10
Activated battery types	25	< 10
Re-chargeable nickel-cadmium battery	12	< 10
Fuel cell battery .	60	> 100
Radioactive battery	10^4	< 10
Nuclear reactor power supply ..	$5x10^9$ (max)	> 100
Fusion power supply	$5x10^{10}$ (max)	> 100
Solar battery	infinite	< 100

As in all space vehicle applications, the primary and most important criterion is weight. Table I expresses some typical energy-per-weight factors.

But energy output per pound is not the only criterion. Depending on

the application the amount of power which can be furnished instantaneously may be important. Here, for example, the solar battery which is best by the weight criterion makes a rather poor showing. The third criterion relates to the total amount of power needed in the vehicle. Different power supplies require different amounts of overhead, e.g. the initial weight investment for a nuclear or fusion power supply is very large so that the supply becomes economical only if the power requirements are fairly high.

At this stage we can discuss the characteristics of the various power sources; their optimum application will then become fairly obvious.

The Leclanche cell or the usual dry battery is not a very efficient device but convenient. It is always ready for use, requires no preparation, evolves no gases, poses no radiation hazard and has a reasonably long shelf life. The same advantages also apply to the *mercury cell* with the additional point that its voltage does not drop until near the end of its useful life. The initial Vanguard vehicles will be powered almost exclusively with mercury cells.

Other one-shot batteries, e.g. silace-zinc cells are more efficient but are best suited for short time applications such as for guided missiles and high altitude rocket flights. They require activation which can at times be inconvenient; they evolve gases which are corrosive. Otherwise they are very similar to the dry batteries, except that their shelf-life is essentially infinite until they are activated. After the electrolyte has been added, their life becomes very short, of the order of 1 or 2 days.

The *re-chargeable batteries* of which the nickel-cadmium or silver-cadmium are the most efficient, have no special advantage for space flight vehicles unless we can supply another power source e.g. solar power or nuclear power, which will recharge the batteries. A typical application therefore would be in a satellite circling the earth which spends about half of its time in the earth's shadow. During that portion the batteries would supply the electrical power and during the daylight portion the solar battery might recharge the storage cells. The storage cells would be useful also for *stand-by duty* e.g. during maintenance or repairs of a nuclear power supply in a manned space vehicle. Storage cells furnish a convenient power package to supply occasional peak loads such as extremely high power bursts for radio communication purposes; it is more economical to store energy in batteries than in condensers.

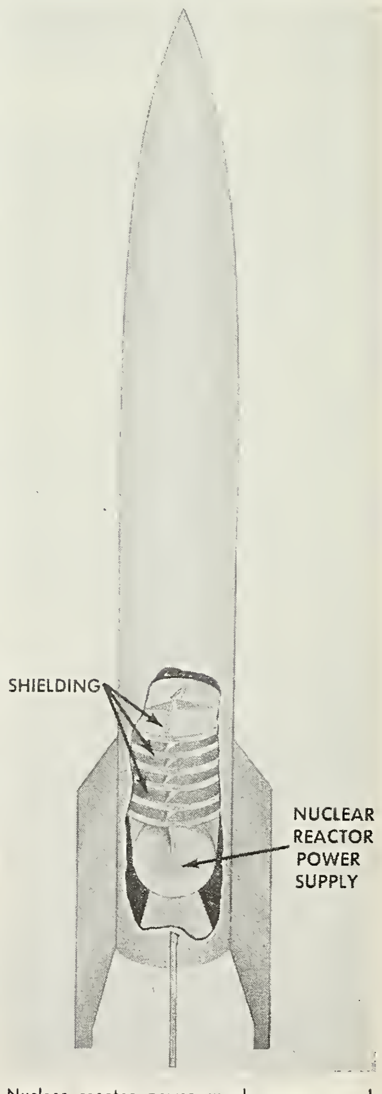
A very interesting type of chemical re-chargeable battery is the so-called *fuel cell* which is being intensively studied in Great Britain. Basically the fuel cell consists of a container for hydrogen gas, another for oxygen and the fuel cell itself which converts the chemical energy of recombination directly into electrical form. The output therefore consists of electrical energy and water. It is perfectly possible then to circulate the water to a nuclear power source which decomposes it again into oxygen and hydrogen by electrolysis and feeds it back into the oxygen and hydrogen tanks. In this way a large nuclear power installation could continuously electrolyze water and recharge fuel cell batteries which could then be used by space vehicles. Such an application would be of importance for example in interplanetary explorations where small exploration vehicles would operate from a mothership. The smaller vehicles might be manned; therefore a nuclear power supply and associated shielding would pose a heavy weight penalty. In this case the fuel cell would be a simpler and more convenient solution of the problem.

Solar Battery

The *solar battery* is by this time well established. It will certainly find its use in small instrumented satellites, possible not in the Vanguard series but certainly soon thereafter. The battery works on the photovoltaic principle with photons from the sun giving up their energy directly in a thin silicon wafer by moving an electron against the built-in potential. Taking the solar energy input at the top of the atmosphere as 1400 watts per square meter and the measured efficiencies of about 10% for the cells now available, one arrives at an electrical power output of about 100 watts per square yard of battery.

It also happens that 100 watts is adequate for the power requirement of the larger instrumented satellites, the meteorological satellites carrying television cameras, and even for satellites which explore the space between the earth up to and beyond the moon.

An interesting method for supplying power at a low level, 5 to 10 watts, is a *radioactive power source.* In distinction to a nuclear reactor this would be a passive source which does not use fission, does not generate any neutrons or additional radioactivity. It simply uses the heat energy from a quantity of material which has been made radioactive and whose activity is now decaying. There is a wide choice of radioactive materials. The important parameters are the *half-life* which must be long enough to compare to the period of applica-



Nuclear reactor power supply sources need only be shielded on the side facing instrumentation or crew compartment.

tion of the power supply; the *mean energy* of the decay, which should be as high as possible; and *availability* since in many cases the overriding consideration will be the cost. For this reason authors always have considered the waste products from nuclear fission reactors.

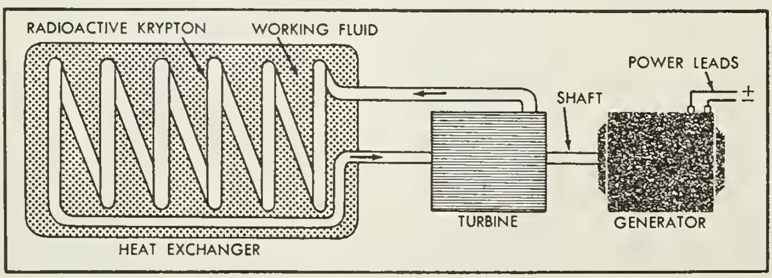
For example, L. Lawrence's Astrosatellite (see MISSILES & ROCKETS, Issue No. 1) uses a strontium 90 radioactive supply. Calculations show, however, that there are special advantages in using gaseous radioactive fission products for satellite power supplies. One of the most promising is Krypton-85. It has a number of special advantages particularly from the safety point of view. It is not stored by the human organism and can be dispersed easily by evaporation into the atmosphere.

Atomic Power

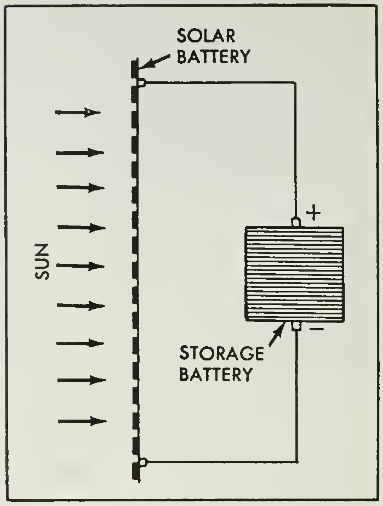
Nuclear reactor power supplies are bound to be of importance for any application requiring more than 100 to 1000 watts. The nuclear power supply is practically without competition. As discussed before it can be augmented with a chemical fuel cell. Basically the nuclear reactor acts as a heat source, approximately one billion B.T.U.'s are produced for every ounce of uranium which is fissioned. This heat must be transferred to a working fluid which then can drive a heat engine. It is well known that the efficiency of a heat engine depends on two temperatures, namely the extremes of its temperature cycle. The nuclear reactor itself can be run very hot, limited only by the strength of materials at high temperatures. However the achievement of a low exhaust temperature may be a problem since there are no means of conducting heat away from a space vehicle. Nearly all of the heat energy must therefore be radiated away into space. A design study has been made by the author which shows that an exhaust temperature in the vicinity of the freezing point of water always can be obtained provided one is willing to build a large satellite and therefore a large radiating surface. Its area in square yards is given approximately by expressing the energy to be radiated in kilowatts.

Another special problem for a nuclear reactor supply is the effect of its radiations on structure of materials, electronic instrumentation and human beings. The structural effects can be designed for and have been by this time well studied. The effects of nuclear radiations on electronic components can be quite severe, particularly on transistors which depend for their operation on the presence of minute traces of impurities. Changes in the internal structure of these transistors will upset their operation. For human beings the tolerance limits are closely specified and must not be exceeded for long periods of time. The two general choices the designer has are: (i) to make use of the inverse square law and put the nuclear power supply far away from the space vehicle instrumentation and occupants; or (ii) to make use of shielding.

Obviously choice (i) is the more efficient method and in the absence of large accelerations is to be preferred, e.g. the reactor power supply on takeoff could be integral with the space vehicle but would be shut off, all of the power being furnished by batteries. On reaching orbit or whenever the propulsion system is off and the acceleration becomes zero, the reactor would be removed to some safe distance from the space vehicle, with only a cable connecting the two. Then the reactor can be turned on by remote control and electricity piped into the space vehicle. Similiarly for landings the reactor would have to be shut off first before it is brought close to the vehicle.



Nuclear power source diagram. Radioactive Krypton is used as working fluid. Conventional turbine and electrical generator are employed.



Simple diagram of solar battery principle. This system may be applicable to small, uninstrumented satellites shortly.

For other applications shielding may be a preferable method for solving the radiation hazard problem, particularly if no human beings are involved. In that case it would pay to make the reactor as small as possible in order to cut down the weight of shielding material; the so-called "fast" reactors developed at Los Alamos would be particularly well suited. Also the vehicle would be designed so that the solid angle subtended by the reactor to the rest of the vehicle is small; in other words a long, thin construction would be preferred. This would make possible the use of a small amount of shielding material, so-called shadow shielding, covering only a fraction of the solid angle and therefore weighing only a small amount.

All of the power sources discussed here are essentially in the prototype stage or beyond, and should be available when required. The futuristic power source, of course, is controlled fusion. When this problem is solved, we will have not only an electrical supply of great efficiency, but one which could make use also of the hydrogen which exists everywhere in the universe. It will then no longer be necessary to carry uranium within the space vehicle.

The abundant amount of electric power which now can be furnished by nuclear supplies and by large solar supplies especially will be important for electrical propulsion schemes such as ionic propulsion. In more ways than one then, the electric power supply problem holds the key to interplanetary flight. ★

World Astronautics

By Heyward E. Canney, Jr.

Dr. Ralph E. Lapp's new book *Atoms and People* (largely on earthbound H-reactors) has brought forward ideas significant to nuclear spaceship propulsion. Dr. Homi Bhabha, an Indian physicist, he noted, predicts that a method will be found for the controlled liberation of fusion energy within the next 20 years. A hydrogen spaceship is far away indeed, but considerable progress seems to have been made in the basic energy problem. In fact, the contents of a recently published Russian progress report on thermonuclear controlled-power have so startled the AEC, that some pressure has been generated to reduce the high secrecy on American thermonuclear work (such as Project Sherwood) which is suspected widely to be hampering progress.

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What may be the nearest thing yet to a real space suit has been recently revealed by the B. F. Goodrich Rubber Company. The wearer breathes 100 per cent oxygen at all times, and has under it a special suit of underwear which provides him with ventilation. Bodily freedom is apparently good, and protection is provided against low atmospheric pressures, high acceleration, heat, cold, and sea water in the event of ditching. This suit has been designed for the Navy, which seems thus far to have been continually in the lead in the design of such equipment.

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Dr. Hubertus Strughold of the USAF School of Aviation Medicine introduced a new term "the ocosphere" which defines that zone in a planetary system within which life-supporting elements occur. In the solar system the zone would lie approximately between the orbits of Venus and Mars and the critical chemical element in question would be oxygen. He reiterated the long-held estimate that there are 100,000 planets in the Universe capable of sustaining life as we know it.

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The "paraballoon", an air-transportable inflatable tactical radar station, developed by Westinghouse, is 30 feet in diameter and weighs 1700 pounds. Air pressures ranging up to 10 psi are used to maintain dimensional stability. Techniques of this kind may well be adapted for future satellites or other space vehicles where large light-weight curved surfaces are desirable. These include parabolic reflectors for microwave radio relay and mirrors for large space telescopes.

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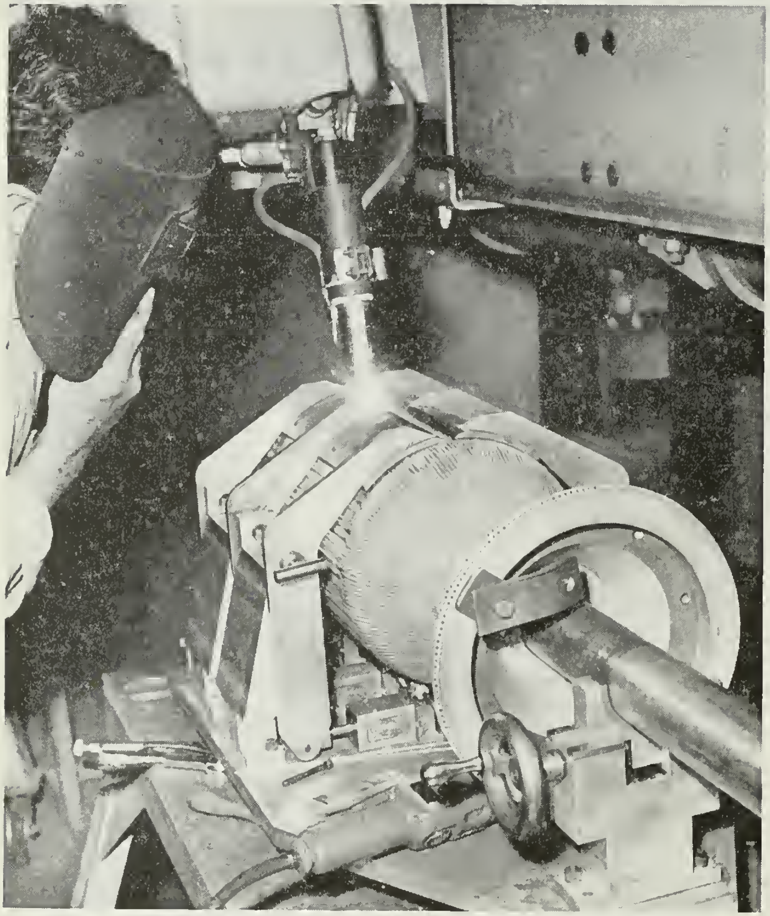
Recent public concern over possible injury from repeated exposures to X-rays has prompted research on the subject. The clinical danger, with good practice, does not seem to be serious, though the question does arise whether or not X-rays from the sun might not prove to be a problem in space.

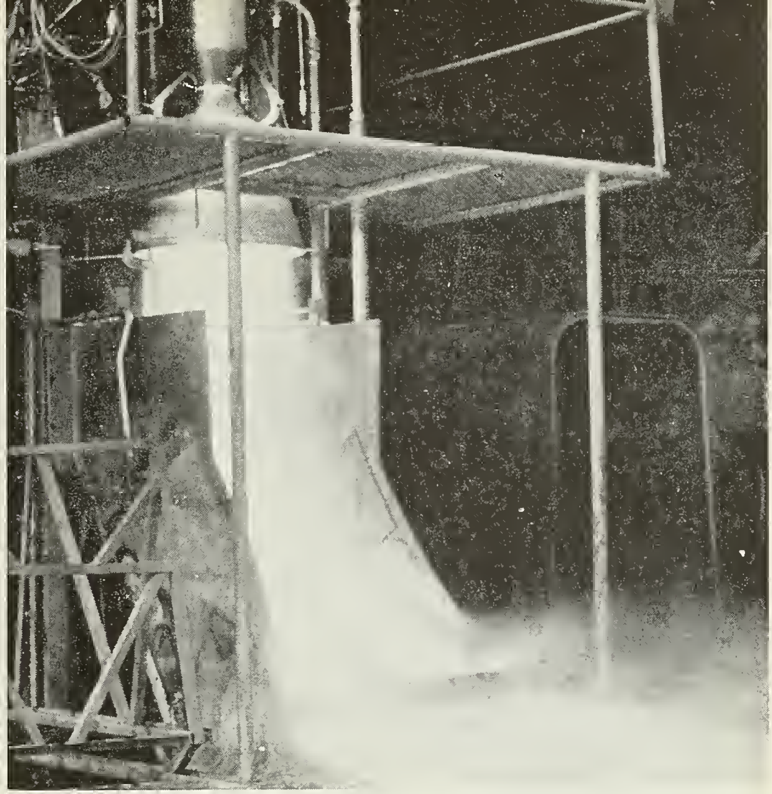


Second Vanguard

Automatic welding of Aerojet's new regeneratively-cooled "spaghetti"-type VANGUARD thrust chamber prior to its being wire wrapped. Aluminum-alloy tubes are used to form the walls of the chamber and also serve as passages for the coolant liquid (oxidizer). Unique design gives considerable saving in overall weight compared to conventional thrust chambers, with no sacrifice in system performance. One of these chambers has been test fired an aggregate of eight minutes—considerably greater than the specific operating duration the second-stage propulsion system will be called upon to deliver.

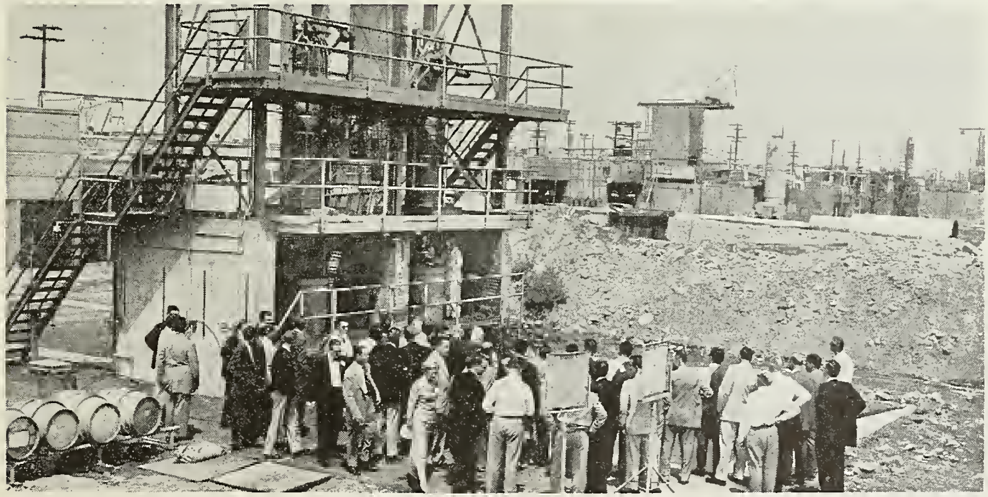
Members of Aerojet-General Corporation's top technical team on the design, development, fabrication, and testing of the second-stage propulsion system for the VANGUARD Launching Vehicle get together around a model of the VANGUARD to consider one of the many difficult engineering problems associated with this pioneering scientific effort. From left to right are C. C. Ross, Liquid Engine Division Manager; W. C. House, Chief Engineer; E. R. Elko, Chief Project Engineer, Missile Rocket Projects; and W. D. Stinnett, Vanguard Project Engineer.

Stage Engine

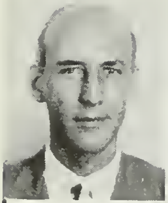


Second-stage thrust-chamber assembly undergoes static test firing at Aerojet's Azusa Plant. Propellant combination used is unsymmetrical dimethyl-hydrazine (UDMH) as fuel and white fuming nitric acid (WFNA) as the oxidizer. This unit provides impulse for the complete second stage (which also houses the inertial guidance system, the third stage, and the satellite itself) to propel it from burn-out of first-stage boost at 36 miles to orbital altitude of 300 miles. The second-stage propulsion system includes integral propellant tankage, the helium-pressurized direct feed system, the gimballed thrust-chamber assembly, and related electromechanical valve and control components. Thrust is almost 10,000 pounds.

Representatives from the Department of Defense, the Naval Research Laboratory, The Glenn L. Martin Company (prime contractor), and Project Vanguard sub-contractors inspect test facility designed and constructed by Aerojet at its Azusa, California, plant for static test firing of second-stage engine. Successful full-scale static test firings have been conducted for durations from 5 to 100 seconds. Engine is designed for 130 second during period.



Newly-constructed test stand at Aerojet's Sacramento plant is shown in final stages of completion. This structure has been activated and is presently being used for full-scale static test firings of the complete second-stage system. Aerojet's Azusa and Sacramento test facilities are both being utilized for VANGUARD component and system evaluation and are currently in full operation.



Propulsion Notes

By Alfred J. Zaehringer

Liquid ozone (LOZ) still hasn't been fired in a rocket motor. Reason: only small amounts have been prepared and LOZ stability is still critical. Armour and Linde have spent several years of research on LOZ preparation and stability, but even purest LOZ detonates. Although not having performance characteristics of LOZ, fluorine-type oxidants have better chances of early test stand runs.

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Look to the solid-fuel ramjet to compete with solid propellants. Several companies are hard at work on this system. One company has had the system under development for over 8 years. University of Detroit's Missile & Rocket Section is working on the thermochemistry of solid-fuel ramjet propellants. Usual fuels: highly compressed aluminum or magnesium metal powders. Reports are that air-fuel specific impulses of around 200 lb-sec/lb have been achieved. Despite long-term work, SF ramjets have "flown" only in tests stands for limited time runs. Although SF ramjets with metallic fuels give highly smoky exhausts, claims are that this is no objection for surface-to-air missiles and would be a tracking aid.

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Another new entry in the solid-propellant field: Propellex Chemical Corp., prexied by Dr. R. A. Cooley who formerly headed Olin Mathieson solid-propellant operations at East Alton, Ill. New Group will locate in the St. Louis area and will develop and manufacture solid propellants (including double base), cartridge systems, and explosive devices.

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Present trends in solid propellants are toward *one* versatile propellant with both high and low-burning rate possibilities and with performance of over 225 lb-sec/lb. Two most widely used oxidants in composite propellants are smokeless ammonium perchlorate (near 225) and ammonium nitrate (near 200), although Aerojet is still using smoky potassium perchlorate (180-190) for many applications. Standard fuel-binders are the polysulfide (Thiokol) and synthetic rubbers (Grand Central, Phillips, and Standard Oil). Development work now is being carried on with epoxy, polyester, polyurethane, and vinyl-type fuel-binders.

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"Pusher" is the large booster rocket development by Phillips Petroleum using same propellant combination used in M15 RATO (see M/R Prop. Notes, Nov., 1956). The 2-ft. diameter rocket has a total length of about 15-ft. Although no data were given, the booster appears to have an impulse rating of below the British RAVEN (about 350,000 lb-sec) and well below the Soviet T-7A (ca ½-million lb-sec).

Problems and Promises of Free Radical Fuels

To bridge the vast energy gap between conventional chemical fuels and the ideal nuclear rocket, efforts are being made to develop a whole new concept of rocket propellants known as free radicals.

The goal is a relatively uncomplicated fuel with, say, 10-to-20 times the per pound energy content of the best rocket propellants now available. Another realistic target is some means for high Mach number vehicles at high altitudes—300,000 feet or more—to "get something for nothing" in the way of propulsive efficiency. Subsidiary, but still important considerations include: Reduction of the gross-launching-weight-to-payload ratio; and the conservation of national resources.

Dissociation Phenomenon

A striking example of free radicals in nature is the phenomenon of dissociation. The skin of a missile flying at Mach 8 at 150,000 feet should theoretically heat up to 6,000°F. But it doesn't. In fact, North American Aviation's Chief Thermodynamicist, Maury Sulkin, says it will zip smoothly, albeit warmly along at an equilibrium temperature of only 1,000°F.

There are two reasons. One is that as the missile body heats up, the more heat fed into the skin; the more heat radiates away. But more importantly, air at this speed hitting and passing over the vehicle dissociates—breaks down first into atomic oxygen and nitrogen; then into charged ions.

These are free radicals. The tremendous energy required to break them loose from their normal stable diatomic molecular state serves to reduce the temperature of the air passing over the skin. But once past the missile and out of its high energy gradient, these particles bounce around, collide and reform into molecules. When they do, all the energy that went into dissociation originally is given back to the air.

The free radical reaction itself is not new. Atomic hydrogen, freed by passing H_2 through an electric arc, has been a chemist's tool for years. It is the desire to utilize this reaction to develop a "conventional" family of fuels that is new.

For example, suppose that ordinary ethane, C_2H_6, has been broken down through the prior application of energy into ethyl free radicals—a rather disorganized mixture of C-C, CH, H, C, etc. Upon ressociation into ethane, it will give off heat energy at the rate of 200 kilocalories per mole. This compares to 33 kilocalories per mole when ordinary JP4 fuel is burned with nitric acid. The ethane reaction is one of the least productive of the free radical reactions. Others with much higher heats of reaction are now being researched. A ressociation reaction, for example, involving ethyl free radicals and oxygen raises the temperature of exhaust gases to over 12,000°F.

Storage Problem

Preparation of free radicals is relatively simple. Apply enough heat or electrical energy and they bust apart. Storage, however, is quite another thing. They are highly unstable—gregarious, as it were, to the Nth degree. Keeping them separated into their free radical state until they are used is one of the main problems now being studied. There are several avenues of possible solution. These include:

- Supercooling down towards absolute zero. The Army, a pioneer in the present work, has succeeded in doing this in the laboratory. Disadvantages of this method include the need for heavy cooling equipment (all right on the ground, but self-defeating in the air), costly cryostat storage facilities and the ever-present danger of an unavoidable catastrophic explosion should temperatures rise to the critical point.
- Magnetic suppression of the free radical gas. A monatomic polarized magnetic field will prevent rotational excitement of the particles and prevent ressociation. This system might be the answer on the ground, but the weight of the permanent magnets would be a handicap to flight.
- Mixing with noble gases such as helium, argon, etc., to keep the highly reactive free radicals separated. Problem is how to filter away the suppressant gas when pure free radicals are wanted for fuels.
- Storage under extreme pressures when standard gas laws no longer apply. Little is known about this phenomenon as yet. But weight of the pressure vessels would again be a likely disadvantage.
- Electro-static separation—similar to the magnetic phenomenon. However, at voltages required corona discharge would probably be a problem. Again, so would the weight of the necessary equipment.

The problem of designing and lining combustion and exhaust chambers to cope with the temperatures involved in free radical reactions. Possible solutions now being studied include the use of very dense ceramics and/or fluorinated plastics. Though the latter do not remain solid at the temperatures involved, the liquid film they form when they melt is chemically inert (whereas free radicals are extremely active chemically and has a very low heat transfer rate. In any case, these liners would certainly have to be replaced after each flight.

If the tremendous air stagnation heat flux at the nose of a hypersonic vehicle could be recovered and utilized to dissociate fuels in flight instead of melting the vehicle's nose cone, the range of any initial fuel load could be immensely increased.

Similarly, at very high altitudes (300,000 feet and up) the air is believed to be 100% dissociated by the energy of ultraviolet radiation. And, while it is very thin, properly designed intakes at high speeds could bring sufficient free radicals to materially assist the internally-carried fuel load. This sounds like getting something for nothing. It isn't. It is merely one possible way of utilizing the sun's radiated energy. ★

Bell Sets Up Guided Missiles, Rockets Divisions

Separate guided missiles and rockets divisions were established last month by Bell Aircraft Corp. in a sweeping reorganization of its Niagara Frontier operations.

Bell's former Niagara Frontier Division has been dissolved in favor of two major operating groups —an aircraft division and weapons systems division. The new missiles and rockets groups will be subdivisions of the latter organization.

Bell president Leston Faneuf said the new set-up has been under study and planning for a year. It is designed to decentralize the company's diversified products business and strengthen product lines.

Vice presidents Julius J. Domonkos and Roy J. Sandstrom will head the aircraft and weapons systems groups respectively. Each will have full responsibility for sales, design, production and procurement for its particular product lines.

In the weapons systems group, the new guided missiles division assumes full control of the GAM-63 *Rascal* air-to-surface missile and other programs.

The rockets division takes over all rocket propulsion design, testing and manufacture.

Two other components of the WS group are avionics and research. The former will handle all of Bell's electronic and servomechanical work. Latter will concentrate on applied research and study contracts, will be in charge of nuclear engineering.

Martin On Schedule In Denver Move

The Martin Co. on November 30 expected to start "on schedule" its move into a new engineering administration building near Denver—site of its *Titan* ICBM airframe production (M/R October, p. 55).

Some 300 employes will transfer to the permanent plant site during the first three weeks of this month.

Martin schedule now calls for completion of its main factory building at the new location late in January. In all, the company now leases six buildings in the Denver area—the most recent a 50,000 sq. ft. structure to be used as a warehouse until the permanent plant is ready for occupancy.

Douglas To Test *Thor* At Sacramento Plant

Component testing of *Thor* IRBM missile will be conducted by Douglas Aircraft Co. at its new test installation under construction on a 1,750-acre plot leased from Aerojet-General Corp. at Sacramento, Calif.

Field station supervisor of new plant will be J. F. Goodman and initial employment is expected to reach 200. First complete *Thor* airframe is now being built.

NAA Head Sees Bright Future For Rocketdyne Div.

J. H. Kindelberger, board chairman of North American Aviation, Inc., views the company's Rocketdyne Division as one of the brightest spots in the North American picture.

Addressing some 1,300 NAA management club members recently in Los Angeles, Kindelberger said the Division has orders to supply engines for all the larger rocket-powered missiles being developed in the U.S. He cited North American's own *Navaho*, Army's *Redstone*, Convair *Atlas*, Martin *Titan* and Douglas *Thor*.

He also noted that Rocketdyne Division employment, now approximately 8,600, is about double that of a year ago and probably will increase another 3,000.

For the present, he added, NAA is the only firm able to deliver proven rocket engines of very high power, but told supervisors the company is going to have to work hard in the future to keep ahead of its nearest competition.

Kindelberger indicated the hope that the *Navaho* missile program will move into a production phase that would demand more of the area and facilities of NAA's Los Angeles Division.

Of another North American missile activity, he classed inertial navigation (guidance) development and production as one of the most favorable aspects of its Autonetics Division activities.

Navigation in Interplanetary Space

October M/R featured an outstanding article on NAVIGATION BY SATELLITES, written by Lovell Lawrence of Chrysler Corporation. His article was based on a paper "Astro—an Artificial Celestial Navigation System," presented at a Franklin Institute symposium and published by the Institute's JOURNAL, in Monograph 2. The response to Mr. Lawrence's article has been so great that M/R decided to pursue this fascinating subject further. The navigation aspect of astronautics has not been considered to any great extent, and we are honored to publish this follow-up feature article, written for M/R by Dr. Peter Castruccio of Westinghouse Corporation. He is currently engaged in advanced planning of interplanetary astrionics communications and navigation aids of the future.

By Dr. Peter Castruccio

DURING the first phase of the development of space flight, it is likely that the navigational aids will be primarily optical, with only limited radio aids. In the second phase of ever-expanding space traffic more automatic means will come into existence and we will witness the ever-increasing use of radionavigation. To navigate successfully, the ship's pilot must know:

1) His position with respect to some frame of reference.

2) His direction of travel with respect to the same frame of reference.

3) His speed.

4) The position of the body towards which he is traveling.

5) The direction of travel of the body.

6) The speed of travel of the body.

7) Any predictable deviations from a straight-line course of the body.

Of course, 4), 5), 6), and 7) must be related to the same frame of reference as 1), 2), and 3).

In space the position of all major celestial bodies is accurately known or accurately predictable. Thus the principal problem of the space navigator is to know his position, direction of travel and speed. This can be done by observing the stars, the Sun or the Planets within the Solar System by means of accurate optical instruments and with the aid of a clock—a method similar to that of the sea navigator when he takes a "fix."

The problems of the space traveler are, however, enormously more complex than those of the seaman. First of all, with the exception of the stars, all his points of reference move continuously. Therefore as soon as he has performed one observation and is preparing for the next his frame of reference has moved. The space navigator then faces a dilemma: if he makes quick observations, his accuracy will suffer; if he takes time and does a good job in observing, his frame of reference shifts too much. If he relies solely on optical measurements, he must consult complicated tables of predicted planet positions, or he must use an electronic computer. At best, his job will be a tedious and painstaking one.

While this laborious procedure is satisfactory for slow ships, it becomes less and less desirable for faster ships. For example, if a ship were to leave Earth under a constant "ig" acceleration, directed to Mars at its closest distance, and halfway during the trip it were to reverse its direction and slow down at the same constant acceleration, the trip would take only 39 hours. Although the motor for such a ship is far beyond our present possibilities, recent announcements, such as Dr. Saenger's photonic rocket, foreshadow what may come.

Navigational systems similar to the ones now employed for airships can be employed in space and, as far as we know today, they should work better because no distortion or deflection of the rays will occur in space. Also, the problem of "radar horizon" caused by the Earth's curvature will not arise. Space navigation is more complicated than earth navigation because while Earth-based navigational aids are fixed with respect to the Earth's frame of reference, space systems must of necessity move with respect to each other because of the constant motion of all planets and satellites.

Different Systems

Nevertheless, such systems can still be conceived in several forms:

1) Beams aimed between planets (or satellites of interest), forming polygons of variable legs, which legs always represent the shortest distance between planets.

2) Very broad beams, or even omnidirectional radiators, placed on the planet of destination.

3) Space Loran or analogous systems.

In cases 1), and 2), the ship's pilot would tune his guidance equipment onto the frequency of the source of destination and close the ON switch; the automatic equipment would do the rest. It is conceivable that tuning could be automatically performed by merely pressing a button corresponding to

the destination. Advantage could be taken of the Doppler frequency shift of the received signal to determine the ship's speed. The accuracy of the beamrider system would theoretically be very high.

With the beamrider system, an antenna of 30-foot diameter operating at a 3-centimeter wave length could theoretically guide a ship from an Earth base to Mars at its closest distance with an accuracy of 10,000 miles. This compares very favorably with accuracies quoted for celestial navigation; however, it is probably unnecessarily high.

Because of the rotary motion of all heavenly bodies, the beam would have to be rotated in synchronism with its home planet or, in the case of an omnidirectional radiator, several would have to be installed on the surface of a planet to avoid casting a shadow when the beacon is turned away from the ship.

The third navigational system is basically an extension of the Loran system in three dimensions. Surface Loran uses three ground stations—it operates basically by measuring the distance from the three fixed stations from the aircraft. If we have three fixed points in a plane and if we know the distance of an unknown point to each of these three points, we can draw three circles, centered on the three fixed points, with their radii equal to the measured three distances. The point of intersection of these three circles gives the position of the unknown point. In space we have three dimensions to contend with instead of two, so we need one more fixed point, making a total of 4 stations.

In the case of Loran, all the computations are, of course, performed automatically within the aircraft. The same would apply to Space Loran. The difficulty with Space Loran, which we do not find in Earthly Loran, is that the stations must move themselves to prevent their falling on some planet or on the Sun, and to keep them in regular orbits.

Their motion must be accurately known, otherwise the entire system becomes useless. To do this one possibility is to install them on planets, satellites, or on artificial satellites (space stations) circling the planets. Another solution is to place them in known orbits around the Sun, which makes the stations essentially artificial planets.

A drawback of this second method lies in the fact that the Loran stations (or beacons) being very light compared to the Planets, may be seriously influenced by the various gravitational forces acting within the Solar system. In fact, some believe that they never could be placed in a completely stable and permanent orbit.

Any erratic motion of great magnitude would of course spoil the advantages of this system. It would thus appear that the best location for Space Loran beacons is on existing celestial bodies whose courses are accurately known and predictable. Even knowing their exact motion, however, does not completely solve the problem. They still have the great disadvantage, with respect to the Earth-based Loran system, of moving continuously. This drawback can be combatted, however, by carrying a computer in the ship which would take their motion into account and correct for it. Special signals could be emitted by the stations at periodic intervals to synchronize the computer, i. e., to correct automatically any errors the computer may have accumulated since the preceding signal

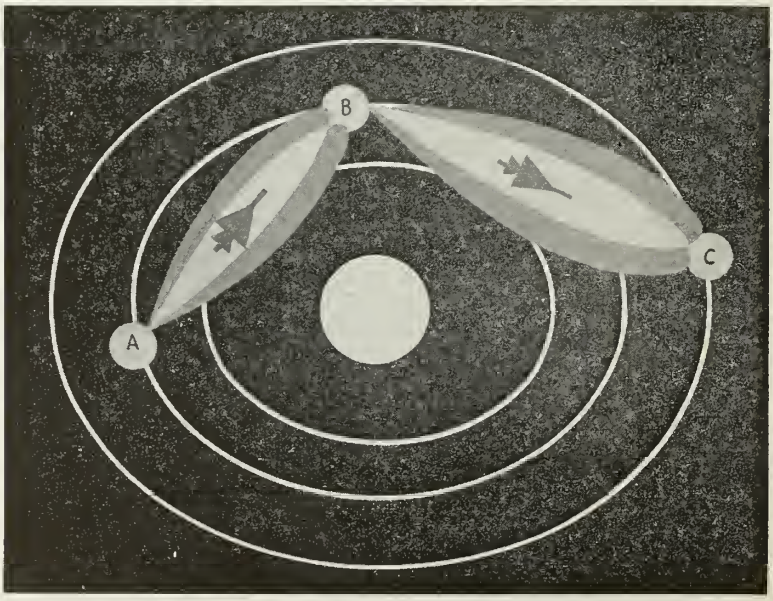
The advantage of the Space-Loran (RAVEN: Ranging and Velocity Navigation) is that it can furnish the space ship an instantaneous proportional fix, whereby the ship can know its position with respect to any point of the Solar System. In addition, RAVEN can furnish the ship its correct speed and direction of travel, by making use of the Doppler effect, i.e. by measuring the difference between the received frequency and the known frequency of the beacon.

All this information can be determined automatically by appropriate instruments within the ship and presented to the pilot by a guidance computer which would calculate, from the information received, the quantities of interest to navigation.

The difference between the first two systems and RAVEN is that while 1) and 2) furnish direct guidance to the destination, RAVEN furnishes only a fix, the pilot must then calculate and set his own course.

Technical Problems

The largest single problem of space navigation is range. Many of our Earthly communications systems are omnidirectional the transmitting antenna sends forth energy in all directions, and the receiving antenna can receive in all directions. This is the typical case for radio or TV, and also for LORAN.



Radio beams between planets will let pilots relax as automatic equipment guides them along shortest route.

It is safe to state that such a system would not be operative in space (except for relatively short distances) with the presently available techniques. The range for voice communication, for instance, with the best equipment available today and with practical size antennas aboard ship, would be about 16 million miles. This is obviously inadequate in view of the fact that the shortest distance to Mars is 36 million miles.

The range for RAVEN can be calculated (with omnidirectional-transmission and reception) at about the same figure. To achieve greater ranges, several means are available—some of these can be used today, others require further development effort but will presumably be operational by 1970. These are:

1) Beaming of the transmitted energy.

2) Beaming of the received signal.

3) Increasing transmitted powers.

4) Improve the sensitivity of the receivers.

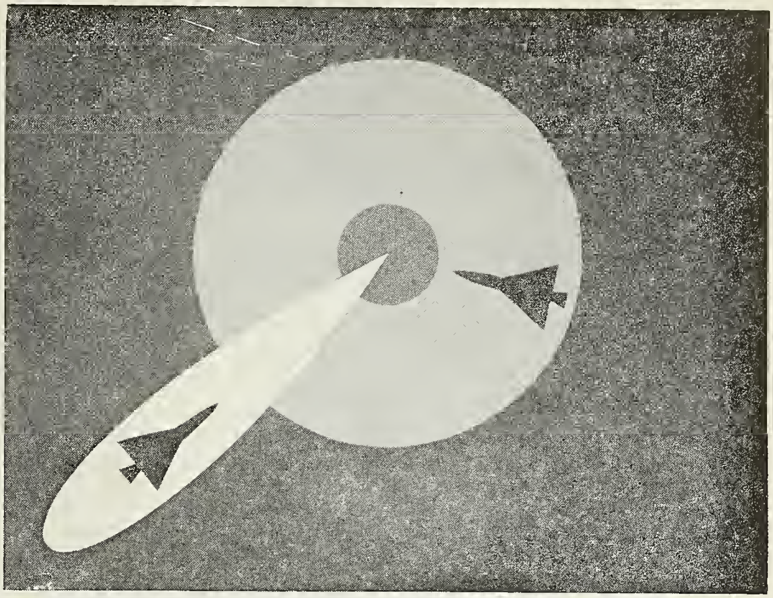
5) Improve the information content of the signal and the means to extract the signal from the background noise.

6) Reduce the quantity of information per unit time, i.e. "spread" the messages out in time and develop equipment capable of taking full advantage of such a technique.

While 1, 2 are immediately applicable today, 3 to 6 require further development. *Beaming*, while it increases the range because it concentrates the energy, has its drawbacks in that the beam must be aimed between the transmitter and receiver. Beaming requires a knowledge of the position of the ship from the base, and vice-versa.

While beaming is obviously necessary for the first navigational method proposed (beamrider) it would not be applicable to the second system nor to RAVEN. With existing techniques, the range achievable with a fully omnidirectional system is about 16 million miles. It is probably not too far-fetched to predict that by 1975 or so this figure can be increased by at least one order of magnitude.

Even with today's techniques, beaming will allow much greater ranges than the 16 million miles quoted above. Even a relatively broad beam, such as 30°, will increase the range from 16 to 160 million miles.



Broad beams and omnidirectional radiators show how proven air navigation methods may be adapted to space travel.

Another technique which is still imperfectly developed but which may well be useable to its full advantage by 1975 is that of *integration.* This technique reduces the quantity of information transmitted by spreading out the message in time. It can be computed that with perfect integration, the range increases as the square root of the message spread in time.

Time Spread System

It is interesting to compare the beaming system with the *time spread* system. It is obvious that the beaming system concentrates the energy in one direction, with a corresponding loss for all other directions; the range thus increases in the beam's direction, but drops in all other directions. If we are transmitting, and we do not know the position of the receiver we wish to contact, we must move our beam until contact is made. In so doing, we must: transmit in a certain direction, wait a sufficiently long time for the message to reach the receiver, wait for the receiver to pick up the message, then wait for the message to be re-transmitted and to reach us. We must repeat this procedure for each new beam position. It is obvious that in doing this we lose time.

If now we compare the beam system with the time spread system in respect to the time required to contact a receiver of unknown position we find that the time spread system, operating at full efficiency, will require less time. Conversely, for the same lost time, the time spread system will reach out further in range.

We can thus conclude that beaming has an advantage over a perfect time spread system only if we know the position or the general area of the receiver to be contacted, so that our scanning time may be rather limited.

It is worth mentioning that the Solar system is very nearly flat and the orbits of the planets all lie approximately in a plane. Space navigation within the Solar system may well be confined within this plane, unless other noteworthy objects be discovered in other regions of space which, in the light of our present knowledge, appears unlikely. Thus, all navigation and communication radiation patterns need be omnidirectional only in azimuth, and confined to a relatively narrow elevation sector. This arrangement would further increase the ranges of all our communications systems. ★

South Africa Prepares for Satellite Tracking

By F. C. Durant III

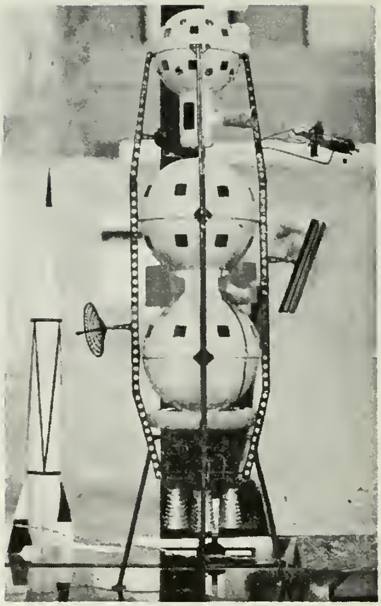
When the U.S. launches its earth satellites from Florida during the International Geophysical Year they will head southeast approximately along a 40° path. In South Africa, eyes will be trained northwest, waiting for them. No one at the southern extremity of Africa waits with more anticipation than members of the young but growing South African Interplanetary Society.

The Union of South Africa will probably be the first land mass of any size to view the U.S. artificial satellites. Their trace will carry them too far to the north to be seen from South America on the first pass. In all probability the satellites will be launched at night to aid official U.S. tracking stations strung out into the Carribean. These early tracking data will be vital in determining the ultimate path of the satellite. Of prime importance will be the direction and velocity at burnout of the third stage of the *Vanguard* satellite launching vehicle.

Less than a half hour later the satellite will have passed over or near the tip of South Africa and will be on its way around the world to pass over the United States about on hour later. If the launching at Cocoa, Florida, were at 10 p.m., the satellite would pass near South Africa after 4 a.m. because of the six hour difference in time zones. Assuming that the time of launching will be in late evening and the early morning skies over South Africa are clear and bright there is a good chance that the satellites will be spotted on the first time around.

The South African Interplanetary Society (SAIS) was founded less than four years ago by a pair of engineers of Johannesburg, A. W. Andersen and Perry Carlson. The first president was A. E. H. Bleksley, professor of applied mathematics, University of the Witwatersrand. Professor Bleksley set forth the functions of the SAIS at the inaugural public meeting in May, 1953. He said the functions are two-fold—"To perform an educational function and to undertake research." The first function involves public lectures and publicity of a conservative nature. Membership qualification of the Society is simply to have a serious interest in astronautics. Technical or professional qualifications are required of Fellow members. Research by the SAIS has been largely academic. A Technical Advisory Committee coordinates such study and performs an advisory function on the various programs.

The SAIS maintains a library at Johannesburg and publishes a quarterly Journal containing original articles, pertinent news of the Society, its activities and items of significance to astronautics. The Journal is interesting and has carried a series of excellent articles entitled "Rocket Propulsion" and "Space Flight" by the first SAIS Technical Director, Dr. J. Venter. The Society has a close relationship with the Astronomical Society of South Africa and cooperated with them at an exhibition in Johannesburg last year. A few months ago a much larger exhibition was held at the "Spring" Festival Show of the Witwatersrand Agriculture Society. The SAIS has been a member of the International Astronautical Federation since 1953.



South African Interplanetary Society conducts exhibits to arouse public interest in forthcoming IGY satellites.

The SAIS membership has just passed the 100 mark. But, the Society has demonstrated that it is foverned by Directors who appreciate the fine distinction between fantasy and actual achievement. This conservative position on the often controversial subject of astronautics has won for the young Society local recognition by membership in the Johannesburg Council for Adult Education and the South African Association for Advancement of Science.

The Union of South Africa is not one of the handful of nations active in rocket and guided missile development. And yet, the average man, whether he be a professional or simply intelligent, has a strong interest in the development of astronautics. This common interest around the world has led to the formation of astronautical societies as foci of discussion and study of the subject, as well as fellowship with like-minded individuals. The South African Interplanetary Society is one of these. Their activity has been exemplary and future growth seems assured. ★

Astrionics

By Henry P. Steier

Big "missing link" in information made public on the scientific part of the *Vanguard* program is the computation facility. A news conference, presumably on the computation part of the program, was scheduled for Oct. 31 by International Business Machines Corp. but suddenly called off. Rumor has it that interservice rivalry is delaying credit-giving to Army and hence to IBM. Indications are that IBM is supplying computer equipment gratis. Even so, Army feels its big part in operating the communication link with the computer is not getting attention it deserves. So, Pentagon clamp-down persists while "security" problems are untangled.

The commonplace dry-cell battery still appears as best hope in the near future for powering small satellite communication links. Jorgen Jensen, Martin Aircraft Co. engineer, recently compared various power supplies and the dry cell came out on top. Dry cells deliver 50 watt hours per pound. Motor generator, chemically powered, delivers same power per pound of fuel but not including weight of machinery. Solar batteries deliver that power per pound but need a complex and heavy control system. Thermocouples also require controls and weight might be a few pounds per watt. Atomic power plants impose severe shielding weight problem because many astrionics components are sensitive to radiation.

Sensitivity of semi-conductors to nuclear radiation needs research. Big gap in information on the subject was indicated at recent IRE meeting on Electron Devices in Washington, D. C. Anyone with information on the subject was asked to leave name and address in a ballot-type box. Pentagon wants to arrange a symposium on the subject at an early date.

Infra-red know-how in firms doing missile guidance work might come in handy in other fields. Aerojet General, Eastman Kodak and Nevada Air Products are interested in applying missile infra-red detection and ranging techniques to civil proximity warning devices for reducing mid-air aircraft collision hazards.

Philadelphia manufacturers have made a generous offer to the IRE Professional Group on Telemetry and Remote Control. They are offering five prizes of $250 each for best technical papers to be presented at the National Symposium on Telemetering scheduled for Philadelphia, Penna. on April 15-17, 1957.

Although not among the first inboard experiments to be made with the *Vanguard* satellites, the question of whether changes in the earth's field during magnetic storms are due to ionospheric currents or to an extra-terrestrial ring current must be resolved. Information is needed for more accurate prediction of magnetic storms that wreck communication. Problem will be weight of the magnetometer. Varian Associates has flown their proton precession magnetometer in rockets. A light-weight version of it stands a good chance of being tried in a satellite.

International News

By Anthony Vandyk

One way to start an argument in Canada is to mention the *Velvet Glove*. The Canadian government's official line on the air-to-air missile project is that it enabled the nation to stockpile know-how in the guided weapons field. Critics say that the *Velvet Glove* should have been named the *White Elephant* because the missile was adopted by the Royal Canadian Air Force despite the expenditure of $24 million on it since 1950. Nonetheless, the government insists that the money was well spent. R. O. Campney, Canadian Defense Minister, has declared that the *Velvet Glove* project paved the way for the nation's industry to manufacture a more advanced type of guided weapon, the American-designed *Sparrow*.

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Visitors to Britain's rocket and missile range at Aberporth, Wales, recently got an unexpected demonstration of the jettison procedure followed when an air-to-air missile failed to fire. After it had launched its first Fairey *Fireflash*, a Hawker *Hunter* could not fire the second. Observers noted a flash as the explosive bolt was detonated and the missile then twisted away from the fighter. The *Hunter* then performed a series of rolls in quick succession to be certain that the *Fireflash* had in fact been jettisoned.

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Plans for the reorganization of Britain's missile program now are almost complete. The FINANCIAL TIMES says that efforts will be concentrated on the development and rapid production of six projects: a medium-range bombardment missile; an intercontinental bombardment missile (using rocket motors of over 100,000 lbs. thrust); a ship-to-surface missile; a ship-to-air missile; a surface-to-air missile; and an advanced air-to-air missile.

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France's prime supplier of rocket motors is Societe d'Etude pour la Propulsion par Reaction, usually known as SEPR. The French Aircraft Industries Association has disclosed that SEPR rockets are to be used in the Dassault *Mirage* and the Sud-Est *Durandal* lightweight fighters as well as in the Sud-Ouest *Trident*. The first French aircraft using rocket power, the Sud-Ouest *Espadon*, was equipped with a SEPR unit and jettisonable rocket fuel tanks.

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E. G. D. Andrews, Chief Designer of Armstrong Siddeley Motors' Rocket Division, pointed out recently that none of the components of a rocket engine use up much energy except the combustion chamber. For example, he said, the turbine which drives the fuel pumps takes only about three per cent of the total energy, whereas the compressor of a gas turbine takes about 60 per cent. So, while the overall efficiency of a gas turbine is greatly affected by the efficiency of its components, the combustion chamber is virtually the key to the efficiency of the rocket engine. As long as the remaining components reach a satisfactory standard of reliability their individual performances do not greatly affect the overall performance of the engine.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

INDUSTRY CHALLENGE:

Case For Reliable Missile Batteries

Exide Industrial Division of The Electric Storage Battery Co., producer of the battery for the first wakeless torpedo, has streamlined its development and manufacturing facilities to meet stepped-up guided missile battery demands.

The company has set up within its own organization a team of specialists devoted full time to the missiles program. Task of this group is to take advantage of basic research findings, combine them with engineering and production know-how in the ordnance field, to come up with advanced missile batteries.

This year Exide created a Missile Applications Div. under RAdm. W. H. Ashford (USN-Ret.) to spearhead its missile program. It collaborates with Exide's engineering group to pick appropriate electrochemical battery systems for specific missiles.

A coordinator of missiles applications engineering has been appointed to expedite availability of new missile batteries from concept to delivery.

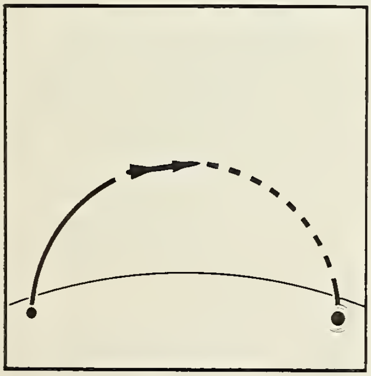
And because of the trend toward use of batteries with alkaline electrolyte in current missiles, Exide has organized an alkaline division within engineering for preliminary design, development and testing of prototypes. Fundamental information for the final design of a missile battery system comes to design engineers from this group.

Another new Exide unit is the Silver Battery Division within its manufacturing department.

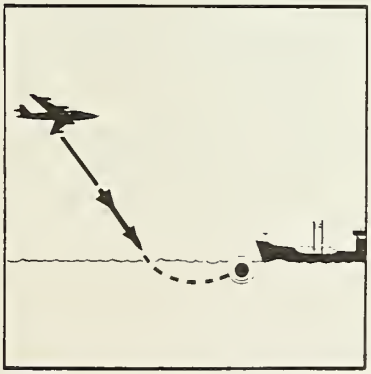
A recognition of the reliability and versatility limitations of mechanical energy sources is shifting missile engineers more and more to reliance on the battery industry to develop power units specifically designed for their intricate applications. Batteries most adequately fulfill these requisites of missile power sources:

- *Maximum reliability.*
- *Maximum energy output per unit of weight and volume.*
- *Precise voltage regulation.*
- *Efficient operation over a*

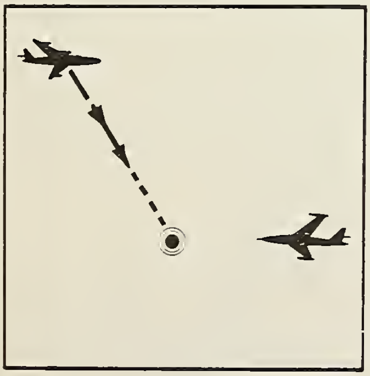
Some Typical Discharge Rates of Storage Batteries in Missile Applications



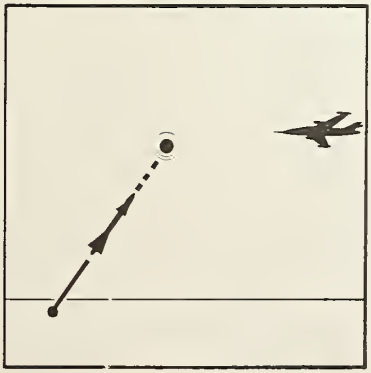
Intercontinental Missile —*60 Minutes*



Air-to-woter — *15 Minutes*



Air-to-Air — *90 Seconds*



Ground-to-Air — *3 Minutes*

Underwoter — *10 Minutes*

wide temperature range.

- *Long shelf life.*
- *Minimum activation time.*
- *Maximum mechanical stability against vibration, impact and other hazards.*
- *Minimum maintenance.*

A choice of electrodes for either primary or secondary battery systems is available. Exide designs, for example, include missile batteries with silver-oxide and nickel-oxide positive plates in combination with zinc or cadmium negatives. These supplement its lead-acid battery systems, including the newer calcium and long-life Silvium alloy batteries.

Of the electrode systems now available, silver-oxide-zinc and nickel-oxide-cadmium batteries are receiving most attention for missile application; but in certain instances other types might be desirable.

Several practical missile battery systems are available, and Exide has been active in the development of the most important types which appear to have missile applicability. Pertinent features of such systems are:

PRIMARY SYSTEM (One-Shot Application)

Silver-Zinc—High specific capacity. Extremely low impedance. Operating temperature from 32 to 160 degrees Fahrenheit. Heaters often supplied for operation at below-freezing temperatures. Excellent storage (up to two years).

Water-Activated Batteries—Have a definite place in certain missile applications, but subject to certain limitations.

Mercury Dry Cell—Better than common dry cell on storage. Low impedance and operation at low temperatures.

Common Dry Cell (Le Clanché)—Convenient, reliable and economical in price. Excellent for high-voltage sources. Maximum safe storage about one year. High impedance causes high specific weight at missile rates. Operates poorly at low temperatures.

SECONDARY SYSTEMS (Rechargeable)

Silver - Zinc — Lightest weight system. Operating temperatures from 32° to 180°F. Non-spill capacity considerably reduced at temperatures below freezing. Maintenance

rather difficult. No ready way to check state of charge. Subject to premature failure from maintenance abuse. Life is short compared with some other secondary systems.

Lead-Acid—Standard for comparison of other systems. Comparatively low in cost. Has application for preliminary or check testing when space and weight are of less importance than economic factors. Capacity can be determined by voltage or specific gravity. Works at temperatures up to boiling. Can be made non-spilling. Heavy. Capacity is lowered at sub-zero temperatures.

Nickel-Cadmium—Long life. Work at temperatures up to boiling (212°F). Gives better performance than other types of couples at sub-zero temperatures. Exceptionally unaffected by maintenance abuse. Heavier than lead-acid missile batteries. Non-spill. Requires maintenance. No ready way to check state of charge.

Primary vs. Secondary

The missile engineer must make a basic decision on whether to employ a primary (one-shot) or a secondary (rechargeable) battery system.

Primary systems have the advantage of completely reserve-type of construction. Active parts of the cell are stored dry, with electrolyte held in a separate compartment, requiring little or no attention.

The system is completely inert until the time of discharge, when a rapid-action mechanism fills the cells from the electrolyte reservoir.

Pre-flight testing to insure battery operation, a routine procedure with secondary systems, is unnecessary with primary batteries. Their high quality makes it possible to predict their reliability. This quality can be assured by proper manufacture and control procedures.

A silver-zinc secondary battery has an obvious role in the early phases of a missile evaluation program, but in the final stages, a primary system is to be preferred. The reliability of a secondary battery can be demonstrated by preliminary discharge. It can be used for preflight testing of the missile control. It is at no disadvantage with regard to weight.

Silver-Zinc System

Generally, the silver-zinc electrode battery—either primary or secondary—is superior to others in missile applications, because of weight, volume and electrical behavior.

Like any other battery, the silver-zinc system is composed of positive and negative plates, separators

and electrolyte, assembled in a suitable container which is shaped to fit the particular missile.

The active material of the positive plate is an oxide of silver. There are two states of silver-oxidation, silver oxide and silver peroxide. Certain operational restrictions make it desirable to use silver oxide—the lower state of oxidation—in secondary battery systems.

The same restrictions do not apply to primary systems, making it possible to use silver peroxide for them. Thus, the silver content of a primary battery can be about one-half that of a comparable secondary battery.

Zinc sponge in plate form is used as the negative active material in both primary and secondary silver-zinc batteries.

The active materials must be distributed and placed within the battery to give maximum plate area and minimum electrical impedance. The physical condition of the silver oxide and zinc affects battery performance. Thus, design, condition of materials and assembly are critical in the manufacture of a silver-zinc battery.

Potassium hydroxide in water, is used as the electrolyte. Higher-strength electrolyte has advantages in battery operation, but at lowest temperatures, lower-strength electrolyte is used. A concentration of 30 per cent potassium hydroxide in water has a freezing point of about —65°F.

The alkaline electrolyte of a silver-zinc cell does not change during the operational cycle. This precludes the use of a hydrometer, as in lead-acid cells, to determine state of charge.

Typical Missile Battery

A typical silver-zinc primary missile battery of proven design is shown in the accompanying photograph. It consists of much more than the cell itself. The battery cells, completely dry and electrically inactive, are surrounded by a heating blanket with thermostat.

The electrolyte for the battery is held in a bag container, separate from the battery cells but within the metal container. Space is provided for a heater and thermostat to heat the electrolyte and hold it at operating temperatures.

A closed pipe connects the

Specific Weights and Volumes of Missile Batteries[1]

	Watt Hours Per Pound	Watt Hours Per Cubic Inch	Operating Voltage
PRIMARY SYSTEMS			
Silver-Zinc[2]	30	1.50	1.35
Water-Activated[3]	28	1.60	1.10
Mercury Dry-Cell	7	0.70	1.00
Common Dry-Cell ...	4	0.37	0.90
SECONDARY SYSTEMS			
Silver-Zinc	30.0	1.75	1.35
Lead-Acid	12.0	1.20	1.75
Nickel-Cadmium	8.3	1.75	1.35

[1] Based on efficiently-designed, complete batteries, with auxiliaries, at missile discharge rates.
[2] Activation system included.
[3] Activation system not included.

electrolyte container with the battery cells. It has a valve or rupturable diaphragm with an opening or breaking mechanism. A pressure differential is maintained between the electrolyte bag and battery cells.

When power is required, activating devices operate to release the electrolyte into the cells. The normal activating impulse is an electrical current of about one ampere for 10 to 20 milliseconds. This power is used to fire one or more squibs, which power the activating devices.

For some applications, a mechanical activating—impulse system is used. For this requirement, internal linkages can inaugurate the flow of electrolyte, or a percussion pinion can be used.

In normal practice, the electrical load is connected to the battery, so that filling of the battery constitutes the closing of the power circuit. The load can consist of electronic gear for filament power and inverter input for plate supply current, actuating devices for flight control, detonating devices and missile motivating power.

A typical set of short-run operating conditions for which such a battery might be designed are:

Current—*Pulsing 12.5 to 45 amperes*
Voltage—*28 maximum to 26 minimum, regardless of pulsation*
Time of Discharge—*120 seconds*
Time to reach operating voltage after activating impulse—*less than one second under load*
Environmental specifications—*MIL-E-5272A*
Storage Life—*Up to two years*
Reliability—*999 per cent, plus*

Silver-zinc primary systems are adaptable to applications in all major types of missiles. They have been used successfully to provide intelligence power for intercontinental ballistic and ground-to-air missiles; intelligence and control power for air-to-air missiles; and control, intelligence and main propulsion power for air-to-water and under-water missiles. ★

Terrier to Get New Launchers

Navy has awarded a $23 million contract to Northern Ordnance, Inc. of Minneapolis to produce missile launchers for a new type frigate to carry the Convair *Terrier*.

New AF Heavy Press Engaged in Missile Work

West coast's first USAF heavy press to become operational—an 8,000-ton Loewy extruder at Harvey Aluminum Co.'s Torrance, Calif. plant—is now producing heavy structural parts of the B-52 and other advanced aircraft and missiles.

New press measures 288 ft. long and weighs 3 million pounds. A 12,000-ton extruder is being assembled at the Harvey installation.

Air Associates Subsidiary Opens New Laboratory

A new research laboratory for advanced electronic development is being established by Electronic Communications, Inc., subsidiary of Air Associates, Inc. in temporary facilities at St. Paul St. and University Pkwy., Baltimore.

A permanent research facility situated in north Baltimore is expected to be completed next spring.

General Dynamics Nets $21 Million

General Dynamics Corp., including its Convair Division which builds the *Terrier* and *Atlas* Missiles, netted $21,076,298 for the first nine months of 1956, up 53.2% over the same period last year.

G-D sales were $691,009,401, higher than the $687,274,182 for the full year 1955. Profit before taxes was $39,139,700 compared to $28,779,390 a year ago.

Corporation's backlog on September 30 stood at about $1.8 billion, highest in its peacetime history. President and chairman John Jay Hopkins forecast that 1956 sales are expected to approximate $1 billion and that those in 1957 will exceed that figure substantially.

Tax Suits Go On Trial, Then Recess Until January

Two test suits involving General Dynamics Corp. and Aerojet-General Corp.'s defense activities came to trial in Los Angeles last month and were promptly recessed until January 16.

Both court actions are directed at Los Angeles County and local municipal governments for assessment of personal property taxes against materials used in completing defense contracts.

General Dynamics Corp. seeks return of $89,558 from the county and $28,763 from the city of Pomona for the 1953-54 tax period. Aerojet's suit asked $120,561 from the county and $32,000 from the city of Azusa.

Basic point of issue is the taxable status of work in process. Firms contend such materials actually belonged to the government and were not subject to local tax. Los Angeles county assessor claims that the materials assessed had not been paid for by the government, hence technically were the personal property of the companies.

Decision to take the claims to court was government sponsored and the two firms were chosen because together they hold virtually every type of defense contract let by the government. However, regardless of final decision of Los Angeles superior court, appeal is considered almost a certainty.

Significance of the test case is evident in the tax sums at stake—some $15,000,000 in personal property taxes in Los Angeles County alone hinge on the outcome.

Temporary recess was ordered to obtain additional information about the assessed property.

Armco To Expand Stainless Output

Armco Steel Corp. has asked Office of Defense Mobilization for a certificate of necessity covering planned $55-million expansion, including rolling and processing facilities for 17-7PH stainless steel.

Armco president R. L. Gray said 17-7PH is in demand by aircraft and missile manufacturers for wings and control surfaces to combat high temperatures generated at supersonic and hypersonic speeds.

Titanium Firm Buys New Plant

Titanium Metals Corp. of America has purchased the Ohio River Steel Div. plant of The Louis Berkman Co. and will convert it into an exclusive specialized facility for rolling and forging titanium. Plant is situated at Toronto, O., 60 miles west of Pittsburgh.

NAA Revamps Autonetics Div.

North American Aviation, Inc. has set up a new reliability and standards department and established engineering activity in five other areas as full-fledged departments of its Autonetics Division.

On the list were guidance, flight control, armament control, flight test and special products. Department managers are: E. A. Holmes III—reliability and standards; S. Y. Eyestone—guidance; D. L. Williams—flight control; J. C. Elms—armament control; D. B. Wright—flight test and G. D. Shere—processing.

C-W Building New Plant For Missile Subsidiary

A 100,000 sq. ft. facility for missile development and manufacture by Aerophysics Development Corp. is one of three new plants being activated by Curtiss-Wright Corp.

The ADC addition represents new building construction. Other plants being activated were leased from Studebaker-Packard at Utica, Mich. and South Bend, Ind. and provide more than 1-million sq. ft. each.

Raytheon Gets $35 Million Army Electronics Contract

Raytheon Manufacturing Co., Waltham, Mass. has been awarded contracts by Army totaling about $35 million for further development and production of electronic military equipment.

The new award presumably involves production of the *Hawk* surface-to-air missile, although exact terms of the contract were not disclosed. Army indicated $6 million is to be used for plant preparation and tooling.

Last month Raytheon received a $60-million Navy contract to produce *Sparrow III* air-to-air missiles (M/R November, p. 104).

Olin Mathieson 9-Month Net At $14.2 Million

Olin Mathieson Chemical Corp. reports net earnings of $14,299,715 on sales of $155,491,766 for its third-quarter ending September 30. This compares with a net of $12,514,568 on sales of $138,340,735 for the same period last year.

Nacimco—New Missile Instrument Firm

A team of four ex-Convair engineers have joined with C. L. Rubesh, owner and operator of National City Machine Co., to organize Nacimco Products, a new aircraft firm in San Diego.

Principal fields of interest will be ground and airborne technical instrumentation systems for aircraft and missiles; research on specialized engineering, and precision parts and tooling for aircraft manufacturers.

Convair engineers associated with the venture are R. C. Greenbaum, former senior electronics engineer, as chief engineer; W. D. Howell, former Convair senior buyer, as general manager; J. E. Elliot, a Convair flight test engineer, as design engineer; and, J. L. Shumway, ex-Convair flight test engineer, as research physicist.

Facilities Picked For *Atlas* Testing

Convair has designated four separate facilities to be used for testing its Air Force *Atlas* intercontinental ballistic missile when trials begin sometime within the next 18 months.

Two sites are Convair facilities in San Diego—one for testing missile components situated near Point Loma, and another in Sycamore Canyon for engine tests without firing complete missiles.

Also, at Edwards AFB, engine runs will be conducted and missile systems operated, without launching a vehicle. Convair will have a staff of 500 at this location.

Actual test firings will take place at Patrick AFB, Fla. where it will expand its staff to about 450.

In all, Convair will employ 1,000 in the test program alone and another 7,000 in production at its $40-million Astronautics plant being built in San Diego.

Motorola Gets New Transistor Contract

Army Signal Corps Supply Agency has awarded a $1 million contract to Motorola, Inc. for transistor development.

Project will be undertaken by company's Phoenix, Ariz. Semi-Conductor Products Div.

Boeing Options Plant To Build *Bomarc*

Boeing Airplane Co. has negotiated a purchase option agreement with Ford Motor Co. on the latter's Richmond, Calif. plant as an alternate site for its production of *Bomarc* surface-to-air missiles.

Earlier, Boeing had investigated two other locations—one in San Leandro, Calif. and another in Salt Lake City for *Bomarc* production. Last year the company settled on its Wichita, Kans. facility to build the missile, but a step-up in production of the B-52 there touched off the search for a new plant.

Final decision to buy the Ford facility will be made in the near future, according to Boeing president William M. Allen. If option is exercised, Boeing initially plans to use it for *Bomarc* assembly operations.

AF Missile Facility Gets New Computer

Air Force's Patrick AFB, Fla. Missile Test Center has introduced a new mechanical computer in its instrumentation system to speed the use of data from one firing in planning another.

Unit is designated FLAC (Florida Automatic Computer), has a memory of 4,096 words and can do 1,750 computations per second. Device was developed by Radio Corp of America. RCA will operate it under AF contract.

Prime Contracts to Drop For Small Business

Small business enterprises stand to get a lesser share of Defense prime contracts as more and more defense dollars are spent on aircraft and guided missiles, according to Asst. Defense Secretary Robert Tripp Ross.

Ross indicated it will be necessary for such firms to obtain much of their defense business in the future as subcontractors.

Ross told a Small Business Opportunity Meeting in Cleveland that there is not a single known small business supplier for aircraft and guided missile items costing $10,000 or more. However, the Defense Preferential Planning List shows the USAF has 73 such items for aircraft and nine for missiles.

McDonnell Sales Up, Backlog at $711 Million

McDonnell Aircraft Corp., a key figure in the *Talos* and *Green Quail* missile programs, reports a substantial boost in sales and net earnings for first quarter ended September 30.

Earnings were $1,738,978 on sales of $57,299,735 compared with $1,234,574 and $41,454,685 respectively for the like period in 1955.

A new $58-million order for F3H-2N *Demon* fighters boosted firm's backlog to a record $711,918,860 compared with $601,032,299 a year ago.

New ARDC Agency Aids Small Business

A new procurement agency—Executive for Small Business—has been set up by USAF's Air Research and Development Command to step up the utilization of small firms having R&D technical capability.

New office will be based at ARDC headquarters in Baltimore but will have representatives at the AF development field offices (New York, Washington and Los Angeles) and in the procurement section of each ARDC center. Plans call for additional representatives at other strategic points throughout the United States.

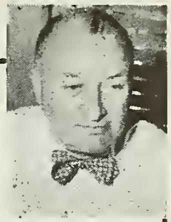
Plan is to have ESB serve as a one-stop counseling service for representatives of small business. In return, however, the AF command expects to gain greater access to source information about firms with potential R&D procurement possibilities.

C/L Shifts NAA Pay 13 Times in Six Years

Recent 2¢-per hour pay hike at North American Aviation marked the thirteenth time since 1950 that cost-of-living allowance has affected its pay scales.

Of the 13, 10 have been pay increases ranging from one to seven cents and two have been decreases—one for 1¢ and another for 3¢.

Most frequent activity occurred between 1950 and 1952 when the Bureau of Labor Statistics' consumer price index increased 13.4%. Since then it has increased only 2.6% in four years.



Industry Highlights

By Fred S. Hunter

If you would like to work in a cave, file your application with the Rocketdyne division of North American Aviation. Rocketdyne's warehouse at Neosha, Mo., where it will produce rocket engines for the Air Force's ICBM program, is a huge underground room, 52,000 square feet in size, quarried in the side of a limestone hill. Ceiling of this unique facility is limestone 28 feet above the asphalt floor and is supported by huge stone pillars left in place by the mining operations. A railroad spur runs into the cave, which has 20 acres of space for additional warehousing. It's quite a set-up, complete with automatic sprinklers in the roof, high-type light and a silica jell humidifier to maintain constant moisture control. The air conditioning is natural; the cave has a constant temperature of approximately 65 degrees.

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Navy's infra-red *Sidewinder* air-to-air missile is as inexpensive as it is said to be efficient. This remarkable weapon, developed under the guidance of Dr. W. B. McLean, technical director of the Naval Ordnance Test Station at China Lake, will cost only about $800 in quantity production. *Sidewinder* is 9 feet 5 inches long and weighs about 155 pounds. It is powered by a solid-propellant motor and has a speed of about Mach 2.5. Reports say it not only has shot down a larger missile, probably a *Matador,* but that it has also split a target *Sidewinder.* Dr. McLean's idea, when he began work on the *Sidewinder* project several years ago, was to develop a missile that could be handled on shipboard almost as simply as 25 inch shell. How well he succeeded is illustrated by the fact that the way to test a *Sidewinder's* combat readiness is to wave a flashlight in front of it. If it sounds a warning buzz like a rattlesnake and its nose seeker whips around following the light, the missile is ready.

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Lockheed's Missile System division has developed a new timing generator for cameras used to record missile flights. In tests, the 2¼-ounce unit has withstood acceleration loads exceeding 100 Gs and temperatures ranging from minus 65 to near-boiling 185 degrees. The device, which is installed as a basic part of a recording camera, marks the film through use of a light-conducting "optical probe." This marking system, says its inventor, Lockheed electronics engineer James T. Path, is practically unaffected by shock, temperature change or film speed. First use of the timer will be in GSAP camera modified for data recording and in the Wollensak Fastair high-speed missile camera. Lockheed has applied for a patent on the timer and has licensed Electromation Co. in Burbank to manufacture it.

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Hughes Aircraft Co. had so much success with its control systems reliability road show last year, it sent out a second road show this year. This time it is the GAR-1 *Falcon* and currently is on the final lap of a 12-week tour. Show consists of a large display for exhibit inside shop areas of component sub-contractors; a smaller unit for lobby display; a talk illustrated with slides; a color movie, and miscellaneous literature for hand out to employees. Purpose is to impress employees of vendors and subcontractors with the need for building quality and reliability into the *Falcon.* Workers have a better understanding after witnessing the show, Hughes says.

SUBCONTRACTORS' GUIDE TO MISSIL

STATE	FUEL	ENGINE	BODY
ALABAMA	Rohm & Haas; Thiokol	Redstone Arsenal; Thiokol	Redstone Arsenal
ARIZONA			Goodyear Aircraft
CALIFORNIA	Aerojet; Ramo-Wooldridge; Grand Central; St'd Oil of Calif. Olin-Mathieson; RMI	Aerophysics Development; Aerojet; Marquardt; Rocketdyne; Ryan; Ramo-Wooldridge; Grand Central; Cooper Development; Raytheon; Olin-Mathieson; RMI; Firestone	Aerophysics Development; Aerojet; Convair, Douglas; Hughes; Lockheed; NAA; Northrop; Radioplane; Ryan; Ramo-Wooldridge; Cooper Development; Raytheon; Norris Thermador; Hunter Douglas Alum.
COLORADO	Ramo-Wooldridge	Ramo-Wooldridge	Ramo-Wooldridge; Martin
CONNECTICUT	Olin-Mathieson	Pratt & Whitney; Lycoming-Avco; Landers, Fary & Clark	
DELAWARE	DuPont; Hercules Powder		
ILLINOIS	Olin-Mathieson	Rock Island Arsenal	
INDIANA	St'd of Indiana	Bendix; Allison-GM; Munice Gear Works	Bendix
KANSAS			Beech; Boeing
KENTUCKY	National Distillers		Reynolds Metals
MARYLAND	Olin-Mathieson; Allegany Ballistics Lab.	Fairchild	Martin; Fairchild
MASSACHUSETTS		GE	Raytheon; Avco
MICHIGAN	Dow Chem.; American Rocket;	Continental Motors; American Rocket; Universal Machine; Tecumseh Products; Utica Bend	Chrysler; Utica Bend; Brooks & Perkins
MISSOURI	Propellex Chemical	McDonnell; Rocketdyne	McDonnell; Emerson Electric
NEW JERSEY	RMI; Thiokol; M. W. Kellog	American Power Jet; RMI; Thiokol; ACF Ind.; Propeller Div., Curtiss-Wright; Wright Aero.	
NEW YORK	Olin-Mathieson; Cornell; Allied Chemical; Shell; Union Carbide; Air Reduction; Buffalo Electro-Chemicals Linde Air Prod.	Fairchild; Bell; Cornell	Sperry-Gyroscope; Fairchild; Cornell; Eastman Kodak; Republic; Bendix Scintilla; Western Electric
NORTH CAROLINA	Oerlikon	Oerlikon	Oerlikon; Douglas;
OHIO	Olin-Matheison; RMI	GE; Goodyear; Thompson Prod.; Colson Corp.; Olin-Mathieson; RMI	Firestone; Crosley Avco
OKLAHOMA	Bell Oil & Gas; Phillips	Phillips	
PENNSYLVANIA	Penn Salt; Air Products	Penn Salt; Lycoming Avco	GE; Philco; Alcoa
TENNESSEE			Crosley Avco; Sperry Farragut; Raytheon
TEXAS	Phillips	Anderson, Greenwood; Phillips; Varo	Chance Vought; Temco; Varo
VIRGINIA	Atlantic Research	American Machine & Foundry; Atlantic Research	
WASHINGTON			Boeing
WEST VIRGINIA	Westvaco		

PRODUCTION AND TYPICAL CONTRACTORS

Raw Materials Sources

MATERIALS	A	B	C
anthracite	√		
bit. coal	√		
lignite	√		
helium	√		
hydrogen	√		
natural gas	√		
nitrogen	√		
oxygen	√		
petroleum	√		
uranium		√	
aluminum	√		
antimony		√	
arsenic	√		
beryllium	√		
bismuth			√
cadmium		√	
cesium			√
chromium			√
cobalt			√
columbium			√
copper		√	
gallium	√		
germanium	√		
gold		√	
hafnium	√		
indium	√		
iron ore	√		
lead		√	
magnesium	√		
manganese	√		
mercury		√	
molybdenum	√		
nickel		√	
platinum metals			√
potassium	√		
rare earth metals	√		
rubidium			√
sodium	√		
selenium	√		
silver		√	
tantalum			√
tellurium	√		
thallium	√		
tin			√
titanium	√		
tungsten			√
zinc		√	
zirconium	√		
asbestos			√
barium	√		
boron	√		
bromine	√		
chlorine	√		
corundum	√		
diamonds (ind.)			√
fluorspar		√	
graphite	√		
iodine	√		
jewel bearings	√		
kyanite	√		
lithium	√		
mica			√
nitrates	√		
phosphates	√		
potash	√		
quartz (radio)	√		
salt	√		
steatite talc	√		
strontium	√		
sulfur	√		

A—Continental U.S.
B—U.S., Canada, Mexico.
C—Overseas dependence.

The millions now spent yearly on direct operational procurement of vehicles with names like *Talos, Nike, Jupiter, Sidewinder,* etc., will soon be billions.

If aircraft require the extensive services of a diversified industry, so do missiles to an even greater degree. All the skills and materials required for airplanes are needed for missiles, plus a great deal more.

The speeds and environments of missiles exceed those of manned flight to a point where, as in the case of the ICBM, they approximate those of meteors.

Optimum solutions to the problems facing designers, engineers and production experts in the missile field have yet to be found. They lie in the great wealth of knowledge and ingenuity that resides in the great and varied mass of American industry. Similarly, materials that never flew before, may tomorrow be the main structural and skin materials of missiles.

More than ever before, the missile subcontractor both current and potential plays a vital role not only in supplying the prime contractor with the bits and pieces and components he specifies, but also is relied upon heavily for new ideas, approaches, suggestions, inspirations.

Thus, we consider this table not only a service to the subcontractor who, we assume, is always interested in new markets, but also we feel it is a service to the missile industry as a whole, in that it will facilitate the flow, exchange and cross-fertilization of ideas that are needed if U.S. supremacy in the field is to be maintained.

The companies listed do not include all of the prime contractors (guidance suppliers are to be covered in the January issues of M/R). Rather, the companies listed are typical of those that are pioneering in this field. They are the main elements concerned with fuels, engines and missile bodies.

* * *

FOR ADDRESSES OF TYPICAL CONTRACTORS, SEE NEXT PAGE.

Information in this guide is derived by m/r's research department from industry, official and semi-official Government sources. In future issues of m/r similar data will be supplied on manufacturers of guidance systems, launching gear and other major missile components and systems.

TYPICAL MISSILE CONTRACTORS

ALABAMA

Redstane Arsenal Research Div.
U.S. Army
Wilbur Davis, Chief
Procurement & Contracting
Huntsville, Ala.

Rahm & Haas Co.
A. H. Belcher, Pur. Dept.
Redstone Arsenal Research Div.
Huntsville, Ala.

Thiakal Chemical Corp.
Redstone Arsenal Div.
Huntsville, Ala.

ARIZONA

Gaadyear Aircraft Carp.
(Goodyear Tire & Rubber Co.)
W. E. Green, Customer Rel'ns
Litchfield Park, Ariz.
(30 mi. North of Phoenix)

CALIFORNIA

Aerophysics Develapment Corp.
(Curtiss-Wright)
Arnold Grim, Contract Admin'r
924 Lobero Hotel Bldg.
Anacapa St., P. O. Box 689
Santa Barbara, Calif.

William Healey, Chief
Material & Procurement
P. O. Box 689
Santa Barbara, Calif.

Aerojet-General Corp.
(Gen'l Tire & Rubber Co.)
F. H. Gebhart, Pur. Agent
P. O. Box 296
Azusa, Calif.

Canvair-Astranautics
(General Dynamics Corp.)
C. F. Uhden, Mgr. of Material
San Diego 12, Calif.

Canvair-Pomona
(General Dynamics Corp.)
O. W. Connell, Pur. Agent
P. O. Box 1011
Pomona, Calif.

Douglas Aircraft Co.
Edw. Curtis, Dir. of Contracts
Santa Monica, Calif.

Hughes Aircraft Ca.
Aircraft Div.
M. E. Taylor,
Director of Procurement
Culver City, Calif.

Lackheed Aircraft Carp.
Missile Systems Div.
J. B. McChesney
Sunnyvale, Calif.
R. M. Robertson
7701 Woodley Ave.
Van Nuys, Calif.

Olin-Mathieson Chemical Corp.
Aviation Division
J. M. Rogers, West Coast Mgr.
1373 Westwood Blvd.
Los Angeles, Calif.

Reaction Motors, Inc.
J. M. Rogers, West Coast Mgr.
1373 Westwood Blvd.
Los Angeles, Calif.
(Joint office with
Olin-Mathieson)

Firestone Tire & Rubber Co.
Guided Missile Division
J. D. Easterly, Mgr.
811 Seville Ave.
Huntington Park,
Los Angeles County, Calif.

Marquardt Aircraft Co.
R. C. Travis, Mgr. Material
16555 Saticoy St.
Van Nuys, Calif.

North American Aviation, Inc.
M. A. Starr, Material Dir.
12214 Lakewood Blvd.
Downey, Calif.

Northrop Aircraft, Inc.
D. F. Beck
Chief Purchasing Agent
1001 E. Broadway
Hawthorne, Calif.

Radiaplane Ca.
P. I. Chase, Dir. of Material
Operations Branch
8000 Woodley Avenue
Van Nuys, Calif.

Rocketdyne Div.
North American Aviation, Inc.
E. F. Brown, Manager,
Contracts & Proposals
6633 Canoga Avenue
Canoga Park, Calif.

Ryan Aeranautical Co.
M. K. Smith
2701 Harbor Drive
San Diego 12, Calif.

The Rama-Waaldridge Corp.
Mr. Fran Brown
Purchasing Agent
6245 W. 89th Street
Los Angeles 45, Calif.

Grand Central Rocket Co.
Rick Daenitz, Pur. Agent
P. O. Box 111
Redlands, Calif.

Norris Thermadar Carp.
5217 S. Boyle Ave.
Los Angeles, Calif.

Hunter Dauglas Aluminum
3017 Kansas Avenue
Riverside, Calif.

Cooper Development Corp.
Orin E. Harvey
2626 S. Peck Road
Monrovia, Calif.

Raytheon Manufacturing Co.
Government Equipment Div.
Santa Barbara Lab.
Robert T. Kiely, Pur. Agent
Santa Barbara, Calif.

Missile Systems Div.
Pt. Mugu Plant
Fred H. Moore,
Materials Manager
Pt. Mugu, Oxnard, Calif.

Standard Oil Co. of Calif.
R. F. Bradley, Manager
Aviation Division
Standard Oil Bldg.
San Francisco 20, Calif.

COLORADO

The Glenn L. Martin Co.
Denver Division
Roth B. Hooker, Dir.
Procurement and Facilities
P. O. Box 179
Denver 1, Colorado

The Ramo-Wooldridge Corp.
(under construction)
Purchasing Agent to be named
Room 414, 1845 Sherman St.
Denver 3, Colorado

CONNECTICUT

Pratt & Whitney Aircraft
(United Aircraft Corp.)
Bert J. McNamara, Pur. Mgr.
400 Main Street
East Hartford 8, Conn.

Lycaming Division
Avco Manufacturing Corp.
George J. Rapuano, Pur. Mgr.
Stanley Brodhead, Sales Mgr.
Prime Contracts
550 S. Main Street
Stratford, Conn.

Landers, Frary & Clark
47 Center St., New Britain
Hartford, Conn.

Olin-Mathieson Chem. Corp.
Winchester-Western Div.
W. Miller Hurley
Div. V.P. and Gen. Mgr.
275 Winchester Ave.
New Haven 4, Conn.

Nuclear Fuels Division
Edward Hartshorne, Gen. Mgr.
275 Winchester Ave.
New Haven 4, Conn.

DELAWARE

Hercules Powder Ca., Inc.
917 Market St.
Wilmington 99, Del.

E. I. du Pant de Nemours & Co.
Explosives Dept.
Wilmington 98, Del.

ILLINOIS

Rock Island Arsenal
(U. S. Army)
Joseph Curley
Chief Procurement Branch
Rock Island, Ill.

Olin-Mathiesan Chemical Corp.
Explosives Dept.
Norl A. Hamilton
Div. V.P. and Gen. Mgr.
East Alton, Ill.

Metals Division
Jesse E. Williams
Div. V.P. and Gen. Mgr.
East Alton, Ill.

INDIANA

Bendix Aviation Corp.
Produ ·ts Div., Missile Section
George Wiley, Materials Mgr.
400 S. Beiger St.
Mishawaka, Ind.

Allison Div., GM Corp.
F. J. Giorgianni
Dir., Purchasing, Matr'l C'trl
Plant 3, P. O. Box 894
Indianapolis, Ind.

Standard Oil of Indiana
137 W. 11th Street
Indianapolis, Ind.

Muncie Gear Works
Muncie, Indiana

KANSAS

Beech Aircraft Corp.
A. S. Odevseff, Mgr.
Military Engineering
East Central Avenue
Wichita 1, Kansas

Baeing Airplane Co.
Wichita Division
R. M. Barry
Wichita 1, Kansas

KENTUCKY

Nat'l Distill's Products Corp.
Louisville, Ky.

Reynolds Metals Co.
2500 53rd Street
Louisville, Ky.

MARYLAND

The Glenn L. Martin Ca.
E. D. Carter, Mgr.
Sub-Contracting
Middle River, Md. (location)
Baltimore 3, Md. (address)

Olin-Mathiesan Chem. Corp.
Industrial Chemicals Div.
John Logan, Divisional V.P.
10 Light Street
Baltimore, Md.

Fairchild Aircraft Div.
(Fairchild Engine, Airplane)
Louis Fahnestock, Dir.
Projects Administration
Hagerstown, Md.

Allegany Ballistics Lab.
Cumberland, Md.

MASSACHUSETTS

Raythean Manufacturing Co.
Paul B. Wilson
Dir. Planning, Procurement
Waltham 58, Mass.

Missile Systems Division
Bruce R. Brace, Pur. Agent
Bedford, Mass.

Commercial Equipment Div.
Paul B. Burns, Pur. Agent
Waltham, Mass.

Missile Systems Division
Thos. J. Flannery, Pur. Agent
Lowell, Mass.

Gov't Equip. Division
George E. Larson, Pur. Agent
Wayland, Mass.

Government Equipment Division
Elmer G. Westlund, Pur. Agent
Government Mfg. Plant
Waltham, Mass.

Avco Research & Advanced Development Division
Albert Maki, Ass't to Pres.
208 Union Street
Lawrence, Mass.

General Electric Co.
Aircraft Access. Turbine Dept.
W. T. Coutts, Mgr. Materials
Lynn, Mass.

Small Aircraft Engine Dept.
T. Foy, Mgr. of Materials
Lynn, Mass.

MICHIGAN

Chrysler Corporation
Missile Operations
Magnus von Braun
Gen'l Supervisor
Contract Specifications
P. O. Box 2628
Detroit 31, Mich.

(Continued an Page 134)

(Missile Contractors, Cont.)

Continental Motors, Inc.
M. R. Ramsey, Pur. Agent
Market Street
Muskegon 82, Mich.

Dow Chemical Co.
R. H. Boundy, V.P.
Director of Research
Midland, Mich.

Brooks & Perkins, Inc.
J. S. Kirkpatrick
V. P., Research & Develop.
Detroit 16, Mich.

American Rocket Co.
Alfred J. Zaehringer
Wyandotte, Mich.

Universol Machine Co., Inc.
8. L. Scott, Dir. Purchasing
316 Lincoln Street
Fenton, Mich.

Tecumseh Products
955 Brown Street
Tecumseh, Mich.

Utica Bend (Curtiss-Wright)
E. K. Mashell, Dir. Purchases
Utica, Mich.

MISSOURI

McDonnell Aircraft Corp.
W. J. Gamewell, Pur. Mgr.
8ox 516, St. Louis 3, Mo.

Rocketdyne Div., NAA
Neosho, Mo.

Propellex Chemicol Corp.
St. Louis, Mo.

The Emerson Electric Mfg. Co.
J. A. Alles, Purchasing Dir.
8100 Florissant Ave.
St. Louis 21, Mo.

NEW JERSEY

American Power Jet
705 Grand Avenue
Richfield, N. J.

Reoction Motors, Inc.
Warren P. Turner, Director
Application Engineering and
Contracts Division
Denville, N. J.

Thiokol Chemicol Corp.
7B4 N. Clinton Ave.
Trenton 7, N. J.

ACF Industry, Avion Div.
William Bingham
11 Park Place
Paramus, N. J.

M. W. Kellogg Co.
Thomas B. Rees, Pur. Dir.
Foot of Danforth Avenue
Jersey City 3, N. J.

Wright Aeronautical Div.
(Curtiss-Wright Corp.)
J. M. Cowell, Dir. Purchases
Wood-Ridge, N. J.

Propeller Division
(Curtiss-Wright Corp.)
F. W. Moore, Pur. Mgr.
Caldwell, N. J.

NEW YORK

Western Electric Co.
Defense Project Division
220 Churchill, N. Y., N. Y.

Linde Air Products
(Union Carbide & Carbon Corp.)
30 E. 42nd St., N. Y. 17, N. Y.

Sperry Gyroscope Co.
(Sperry Rand Corp.)
W. G. Neumann, Pur. Dir.
Aero Division
F. Baron, Purchasing Agent
Great Neck, L. I., N. Y.

Scintilla Division
8endix Aviation Corp.
W. 8. Wilson, Pur. Agent
Sidney, N. Y.

Fairchild Guided Missiles Div.
(Fairchild Engine & Airplane)
A. W. Doherty, Contract Mgr.
T. W. Ungashick, Sub-c't rep.
Wyandanch, L. I., N. Y.

Olin-Mathieson Chemical Corp.
Liquid Fuels Div.
Dr. L. K. Herndon, V.P. and
Acting General Manager
P. O. Box 480
Niagara Falls, N. Y.

Bell Aircraft Corp.
Norman A. Lomas, Pur. Mgr.
Aircraft Division
Maurice J. Coughlin, Dir.
Procurement, Weapon Syst's Div.
P. O. Box 1
8uffalo 5, N. Y.

Cornell Aeronoutical Lab., Inc.
(Cornell University)
Joseph C. Polizzi, Pur. Agent
4455 Genesee Street
Buffalo 21, N. Y.

Eastman Kodak Company
J. E. Doyle, Dir. Purchases
343 State Street
Rochester, N. Y.

Republic Aviotion Corp.
C. E. Reid, Director
Production, Procurements
Farmingdale, L. I., N. Y.

Allied Chemicol & Dye Corp.
Nitrogen Division
40 Rector Street
N. Y. 6, N. Y.

Shell Oil Co., Aviotion Dept.
J. S. Harris, Aviation Mgr.
50 W. 50th St., N. Y. 20

Union Corbide & Corbon Corp.
30 E. 42nd Street, N. Y.

Air Reduction Co., Inc.
150 E. 42nd Street, N. Y.

Buffalo Electro Chemicals
Buffalo, N. Y.

NORTH CAROLINA

Oerlikon Tool & Arms Corp.
W. B. Buol, Purchasing Agent
P. O. Box 3049
Ashville, N. C.

Douglas Aircraft Co., Inc.
Charlotte Div.
D. J. Bosio, Dir., Materiel
1820 Statesville Road
Charlotte 6, N. C.

OHIO

Crosley Div.
Avco Manufacturing Corp.
Harold Brouse, Products Dir.
1329 Arlington St.
Cincinnati 25, Ohio

Colson Corp.
Elyria, Ohio

Firestone Tire & Rubber Co.
Defense Products Div.
C. D. Smith, Mgr.
1200 Firestone Parkway
Akron 17, Ohio

Olin-Mathieson Chem. Corp.
G. Richard Lott
349 W. First Street
Dayton, Ohio

Reoction Motors, Inc.
G. Richard Lott
349 W. First Street
Dayton, Ohio
(Joint office with
Olin-Mathieson)

General Electric Co.
Aircraft Gas Turbine Div.
Evandale Operating Depart.
F. N. Estes, Mgr.
Materials Assembly and Spares
Evandale, Ohio

W. B. Boyd, Mgr.
Materials, Components,
and Overhauls
Evandale, Ohio

Jet Engine Department
G. E. Hotaling, Mgr. Materials
Evandale, Ohio

Flight Propulsion Lab.
Wayne Wheeler, Mgr. Materiels
Evandale, Ohio

Aircraft Nuclear Prop. Dept.
Dr. A. E. Focke, Mgr. Materials
Evandale, Ohio

Goodyeor Aircroft Corp.
(Goodyear Tire & Rubber)
D. E. Zesiger, Mgr.
Sub-contract Projects
1210 Massillon Road
Akron 15, Ohio

Thompson Products, Inc.
23555 Euclid Ave.
Cleveland 17, Ohio

OKLAHOMA

Bell Oil & Gas
National Bank of Tulsa Bldg.
Tulsa, Okla.

Phillips Petroleum Co.
Rocket Fuels Div.
Bartlesville, Okla.

PENNSYLVANIA

Generol Electric Co.
Special Defense Projects Dept.
Russell W. McFall, Mgr. Eng.
3198 Chestnut Street
Philadelphia, Pa.

Philco Corp.
Gov't & Industrial Div.
William MacMurtrie
Gen. Purchasing Agent
4700 Wissahickon Ave.
Philadelphia 44, Pa.

Pennsylvonia Salt Co.
1335 Chestnut, Whitemarsh
Philadelphia, Pa.

Aluminum Co. of America
New Kensington, Pa.

Air Products, Inc.
S. S. Stewart, Pur. Dept.
P. O. 8ox 538
Allentown, Pa.

Lycoming Div.
Avco Manufacturing Corp.
C. L. Briceland, Pur. Mgr.
Raymond J. Cowden, Sales Mgr.
Williamsport Plant, Wmpt., Pa.

TENNESSEE

Crosley Division
Avco Manufacturing Corp.
Joseph D. Taylor, Works Mgr.
Nashville, Tenn.

Sperry Forragut Co.
(Sperry Rand Corp.)
C. S. Rockwell, V.P. and
Works Manager
Bristol, Tenn.

Raytheon Manufacturing Co.
Missile Systems Div.
Theodore L. Sheldon, Pur. Agt.
Bristol, Tenn.

TEXAS

Chance Vought Aircraft Inc.
W. L. Hoffman, Materiels Mgr.
P. O. Box 5907
Dallas, Texas

Temco Aircraft Corp.
Charles E. Kimbark, Jr.
Purchasing Dept.
P. O. Box 6191, Dallas, Tex.

Anderson, Greenwood & Co.
Lomis Slaughter, Jr.
V. P. and Chief Engineer
1400 North Rice St.
Bellaire, Texas

Phillips Petroleum Co.
Rocket Fuels Division
F. M. Files, Mfg. Branch Mgr.
Air Force Plant 66
McGregor, Texas

Varo Monufacturing Co., Inc.
D. H. Kennington, Dir. Pur.
2201 Walnut St.
Garland, Texas

VIRGINIA

American Mochine & Foundry
Defense Products Group
J. P. D'Arezzo, Div. V.P.
1101 N. Royal Street
Alexandria, Va.

Atlantic Research Corp.
Dr. L. L. Weil, Dir.
Chemistry Division
901 N. Columbus St.
Alexandria, Va.

WASHINGTON

Boeing Airplone Co.
Pilotless Aircraft Div.
N. W. Grigg, Materiel Mgr.
Box 3707
Seattle 24, Wash.

T. D. Teigen, Buyer of
Outside Production
Smith Tower, Seattle 24, Wash.
(Missile Production currently
at Plant II, E. Marginal Way,
Seattle 24, Wash.)

WEST VIRGINIA

Westvaco Chlor-Alkali Div.
Development Department
Food Machinery & Chemical
Corp.
South Charleston 3, W. Va.

Subcontracting Guide to the Electronics and Astrionics Industries Will Be Featured in the January Issue of M/R

Hughes Sales At $300 Million—Backlog $500 Million

Hughes Aircraft Co., prime contractor for the *Falcon* air-to-air missile, has disclosed its annual aviation sales for 1956 will be about $300 million; current backlog is approximately $500 million; and employment exceeds 25,000.

Joseph S. O'Flaherty, manager of Hughes Semiconductor Division, revealed these figures late last month as he spelled out in detail the company's activities in semiconductor production.

The Hughes official estimated the present annual industry sales volume in semiconductors runs between $55,000,000 and $60,000,000 and that Hughes accounts for about $12,000,000, or 20% of the industry total.

He also forecast that industry dollar sales volume in semiconductors will increase five-fold over the next four years, to about $300 million by 1960. At Hughes, the $12 million for 1956 compares to $5,400,000 in 1955. The company's volume has about doubled each year since 1953.

O'Flaherty said Hughes semiconductor division now employs 1,300 persons, works on a two-shift per day basis in six buildings totaling 135,000 sq. ft. of floor space. He attributed the company's entry into this field to the new high standards of performance required in electronic armament control systems and guided missiles it develops and produces for the Air Force.

Market 85% Non-Military

Of the future market potential, the Hughes official expects that the $300 million industry of 1960 will supply about 85% by dollar volume to civilian industrial markets and only 15% to the military. He estimates there are some 40 companies now engaged in producing semiconductors, but that new capital requirements and complexities of manufacture may alter the structure of competition in future years.

O'Flaherty said probably no industry is based so closely on initial discovery and research as is the semiconductor field. Advanced research in solid state physics and the chemistry necessary to produce semiconductors has already passed into a realm of physics beyond the knowledge which produced the A-bomb, the Hughes official points out. "Yet we have only scratched the surface."

"Literally thousands of scientists have a working knowledge of nuclear fission," he adds, but "only a relative handful have a comparable understanding of solid state physics."

Replaces Expensive Tubes

Of the new Hughes products, he said the company's quick-recovery silicon diode represents an engineering modification to overcome the past sluggishness of silicon compared with germanium in handling electrical current.

Hughes other new product, the small power rectifier, has working voltages up to 400 volts. It is planned for use in the place of selenium rectifiers and will do the work formerly performed by large and expensive specialized vacuum tubes, O'Flaherty said.

Both the quick-recovery diode and power rectifier are now ready for large scale production. O'Flaherty feels their development will result in the introduction of semiconductors into new and expanded industrial fields.

North American Nets $28.7 Million

North American Aviation, Inc. reports a net income of $28,760,962 for its fiscal year ended September 30, a drop of 11% from $32,349,176 for 1955. Sales, however, were at a record high—increasing almost 12% from $816,676,329 in 1955 to $913,-981,913 this year.

The slump in earnings was attributed to expansion of its research and development program and an increase in R&D work for the government under cost-type contracts which do not allow substantial profit margins.

Chairman J. H. Kindelberger noted that the company's 1956 appropriations of $23,683,099 for capital construction is the highest in its history.

Among its future prospects for large-scale production, the company cited its *Navaho* intercontinental air-breathing missile, the F-100F two-seat fighter and two new planes being developed for the Navy.

IRE Groups Drop Merger

Question of a merger between the IRE Professional Groups on Telemetry and Remote Control and on Aeronautical and Navigational Electronics has been dropped.

A committee appointed to study the matter has recommended this action. Also, it concluded that the customary meeting of the two groups at the annual Dayton PGANE meeting be eliminated.

The committee said the Dayton meeting has grown too large to permit easy assimilation of additional papers.

New Accelerometer At Northrop

Engineers on Northrop Aircraft, Inc's *Snark* intercontinental missile program have developed a new manometer accelerometer said to be copied after the balance mechanism of the human ear.

Twin tubes of glass hold an electrolytic solution that covers tungsten electrodes in the glass. Connected to a Wheatstone bridge the device acts as a plumb bob to detect deviations in position or changes in speed of a missile. The capsule is temperature controlled for uniform response.

industry briefs

LOCKHEED'S Missile Systems Div. in September received more than $30 million in orders, is now negotiating R&D contracts worth about $60 million.

UTICA-BEND CORP., new Curtiss-Wright subsidiary that is to build Army's Dart missile, was awarded a $4.8 million contract to prepare for receipt and installation of machinery at its Utica, Mich. plant.

LARGE CONTRACT of undisclosed value has been awarded to Radio Corp. of America to develop and produce an air-ground data transmission system for U.S. Air Force.

THE MARTIN CO. was awarded $599,623 by USAF for modification of TM-61 Matador missiles.

LITTON INDUSTRIES, INC. reports earnings of $1,019,703 on sales of $14,920,050 for fiscal year ended July 31. Net was up almost 134% as sales jumped 67%.

AEROJET-GENERAL has redesignated its Electronics and Guidance Div., now calls it Avionics Div. Manager is J. S. Warfel.

AUTHORIZATION TO OPERATE nuclear science facility at Palo Alto, Calif. is being sought from Atomic Energy Commission by Lockheed's Missiles System Div. Purpose: R&D in reactor components.

HOFFMAN LABORATORIES, INC. plans to build a 40,000 sq. ft. electronic R & D building opposite present facilities in Los Angeles. It will house new products engineering staff and a complete engineering library.

GENERAL DYNAMICS CORP. has granted $1 million to Univ. of California for expansion of its La Jolla, Calif. campus to provide graduate program in science.

SERVOMECHANISMS, INC. has leased 13,160 sq. ft. additional space at 8825 Sepulveda Blvd., Los Angeles to house its Western Div. management, engineering, accounting, customer liaison departments.

AUTONETICS DIV., North American Aviation Inc. has moved purchasing and warehousing departments numbering 350 personnel into new 150,000 sq. ft. building at 201 W. Manville, St., Compton, Calif.

PHILCO CORP., co-producer with General Electric of Navy's Sidewinder missile, has purchased Sierra Electronic Corp. of San Carlos, Calif. SEC president Willard Feldscher becomes v.p. and general manager of the wholly-owned Philco subsidiary.

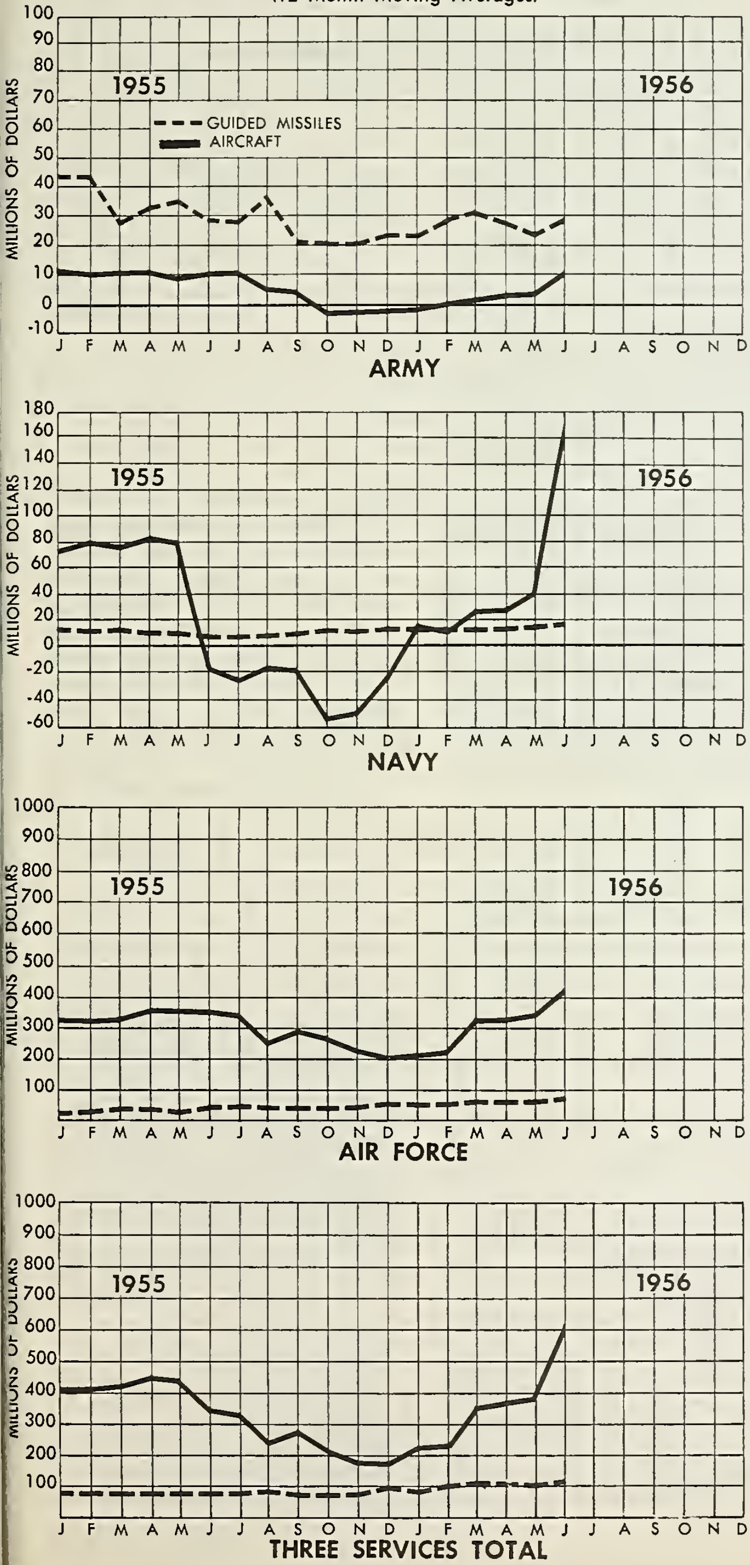
NORTHROP AERONAUTICAL INSTITUTE has broken ground for a 23,00 sq. ft. Engineering Education Building to be situated at Aviation and Arbor Vitae Blvds. adjacent to Los Angeles International Airport.

AMERICAN BOSCH ARMA CORP. reports net income of $3,385,438 on sales of $86,729,566 for nine months ended September 30 compared with earnings of $2,971,878 and sales of $55,660,928 for this period last year. Sept. 30 backlog was $175 million.

TRANSVAL ENGINEERING CORP., specialists in transistorized airborne electronic equipment, has opened its second plant and plans a 5,000 sq. ft. expansion of its main plant in Culver City, Calif.

INDUSTRY BAROMETER

GUIDED MISSILE OBLIGATIONS INCURRED
(12 Month Moving Averages)



Department of Defense is now incurring obligations for guided missiles and missile components at the average rate of $120,518,000 per month (June 1956). This is an increase of $36,012,000 from June 1955, up 43%.

In order to clear up any misunderstanding as to the exact definition of "obligations incurred," the Department of Defense uses the wording set forth in Budget-Treasury Regulation No. 1. Regulation No. 1 defines "obligations incurred" as orders placed, contracts awarded, services received and similar transactions that take place during a given period requiring future payment (expenditures) of money. Due to the complex funding system used by the three Services, it is possible to develop negative obligations which are usually called deobligations. Deobligations occur when past obligations are cancelled faster than current obligations are incurred. Sometimes huge deobligations take place that merely reflect changes in "bookkeeping" procedures. In August of 1954 the President signed Public Law 663. Section No. 1311 defined the basis on which the services should record obligations incurred. Previously, letters of intent were counted as obligations. Letters of intent are now excluded by Section 1311.

At the end of each fiscal year the Services are required to certify both the amount of funds obligated and the unobligated portion. The Navy was the only Service able to complete the tremendous task of removing letters of intent obligations from their books by June 30, 1955. Therefore, their minus obligations (deobligations) for that month reflect not only contracts cancelled, but the purging from the records of letters of intent.

For the effect this procedural revision had on Navy obligations, see the Navy chart of obligations incurred, June-December 1955.

The Army and Air Force, on the other hand, made their obligations readjustment from July through December of 1956.

This bookkeeping readjustment had no effect on DOD contractors,

DEPARTMENT OF DEFENSE OBLIGATIONS INCURRED
(12 MONTH MOVING AVERAGE)

	1955			1956		
	Missiles (000's)	Aircraft (000's)	Missiles as a % of Aircraft	Missiles (000's)	Aircraft (000's)	Missiles as a % of Aircraft
January	$ 88,227	$ 418,044	21.1%	$ 94,330	$ 234,847	40.2%
February	92,493	419,965	22.0%	104,706	240,027	43.6%
March	84,812	431,991	19.6%	110,516	368,616	30.0%
April	86,137	461,390	18.7%	108,402	378,001	28.7%
May	83,562	451,674	18.5%	106,116	396,815	26.7%
June	84,506	356,713	23.7%	120,518	610,674	19.7%
July	84,159	341,084	24.7%	$644,588	$2,228,980	28.9%*
August	94,997	255,170	37.2%			
September	80,876	288,594	28.0%			
October	81,793	216,302	37.8%			
November	81,904	187,258	43.7%			
December	100,554	183,648	54.8%			
Year 1955	$1,044,020	$4,011,833	26.0%			

* 1st 6 months 1956

since letters of intent are generally followed by written contracts.

As obligations incurred fluctuate wildly from month to month, we have employed a twelve month moving average to smooth out the peaks and the valleys while at the same time pointing up any trend characteristics. For a detailed explanation of this statistical technique, see Industry Barometer—November 1956.

Some typical unclassified obligations incurred in 1956 include contracts to Glenn Martin, $14,234,000 for *Matador* missiles (January); Aerojet-General, $9,000,000, facilities for pilot production and production testing of liquid rocket engines (January); Air Products, Inc., $3,910,000, facilities to produce LOX (liquid oxygen) (January); General Electric Co., $5,000,000, development and production of radar antennaes for use in tracking guided missiles (February); Air Products, Inc., $5,768,000, for liquid oxygen and nitrogen (April); North American Aviation, $5,325,000, for facilities for Production of the *Navaho* (April); Hercules Powder Co., $3,610,000, solid propellant rocket systems (May); Convair, $7,715,000, Facilities to support Intercontinental ballistic missile program (June); North American Aviation, $16,152,000, for *Navaho*.

The accompanying graphs and chart show both the rapid rise in Department of Defense missile obligations, $88,227,000 for January 1955; $94,330,000 in January 1956; $120,518,000 for June 1956 and at the same time provide a referential framework comparing these with aircraft and related equipment obligations. Aircraft and related equipment obligations for these same three months were $418,044,000 January 1955; $234,847,000 January 1956; $610,674,000 June 1956.

The Army's average obligations for missiles and related equipment has varied greatly from month to month. High for the period January '55 to June '56 was January 1955's obligations of $45,000,000. Present obligations level is close to $30,000,000. All present indications point to little change in obligations level for the remainder of calendar 1956. Average obligations incurred for the last half of 1956 should hover around the $28-32 million dollars per month.

Missile obligations incurred by the Navy have had only slight fluctuations. Low month for the 1½ years analyzed was July 1955 ($9,509,000). High month was $19,381,000 obligated in June 1956. During the last six months of 1956 chances are good that average missile obligations for the Navy will be accelerated to the $25 million per month level.

The Air Force is currently incurring more obligations than the Army and Navy combined. Average obligations during the last half of 1956 should rise some $25,000,000 per month over June 1956's $72,000,000.★

NEW MISSILE PRODUCTS

MISSILE CHECKOUT SYSTEM

An ultra-rapid missile tester for use in the field has been developed by the Microwave Division of Sperry Gyroscope Co. Known as RACE (Rapid Automatic Checkout Equipment), it is designed to do most of the analytical thinking for military combat technicians.

RACE brings automation into the battle field to keep modern weapons fit-to-fight. It uses computer elements to checkout all parts of a missile system, finds faulty components and delivers a punched card that identifies the fault.

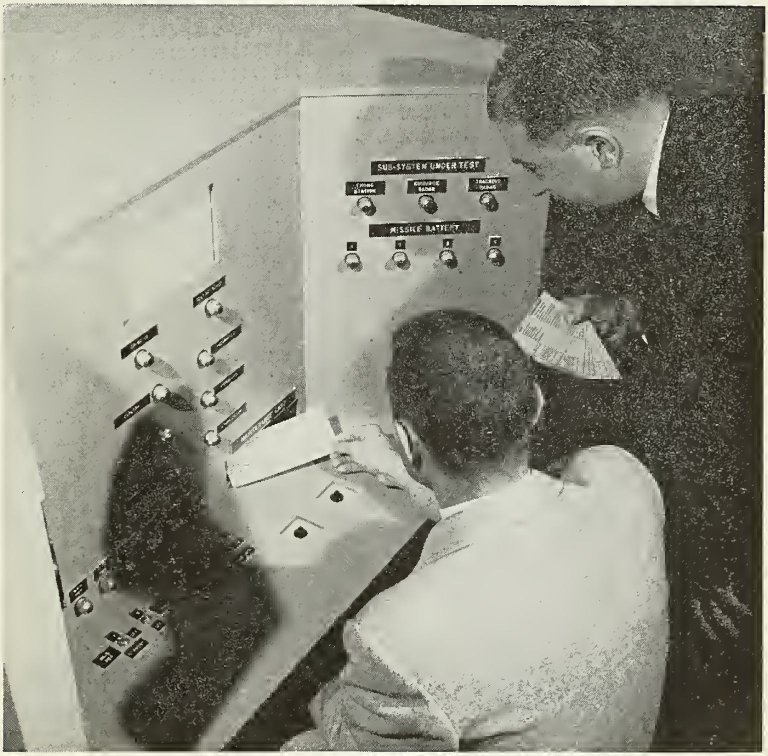
An electronic memory supervises the checkout by controlling generators that transmit test signals to each missile through cables and by microwave radio.

Progress of tests is indicated at a master console. Go-NoGo panel lights indicate progress of the tests and give a "Go" signal at the end if everything is satisfactory.

Electrical, eletronic, pneumatic and hydraulic systems used for guidance, tracking and stabilization are tested in a few minutes. When a fault is discovered, lights on a master test console pin-point the fault. At the same time a punched card is delivered.

The card shows the fault and the maintenance procedure for curing it. In this way rapid plug-in replacements can be made or the missile excluded from the battery if repair time is too long.

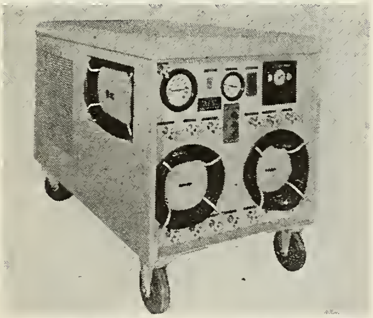
One of RACE's features is simultaneous test of slow and fast reacting circuits. With this feature RACE does not have to wait upon slow acting components that would increase test time. Write: Sperry Gyroscope Co., Microwave Div. Dept. M/R, Great Neck, N. Y.



The RACE missile tester console shown delivering a punched card for use by a technician in rapid repair of a missile component.

PNEUMATIC CART/AIR STAND

Two new pieces of aircraft and missile support equipment, a high-pressure air bottle cart and a mobile high-pressure air stand, have been unveiled by Accessory Controls & Equipment Corp.



The ACE-37 cart is rated for 3,600 psi pressures, has a capacity of 18,000 cu. in. and weighs about 2,000 lbs. It measures 42" high, 38" wide and 60" long.

The ACE-36 air stand is designed to provide a 5,000 psi source of dry air for starting jet engines and calibrating instrument systems. It supplies capacity to dry 16 cfm by means of a refrigerant-type dehumidifier and desired dryness may be selected by adjustment of a thermostat setting.

For rocket and missile applications, it is capable of boosting nitrogen to pressures of 6,000 psi.

The stand has two supply systems—one to serve for direct loading of air bottles and a second that may be regulated automatically for any pressure from about 100 to 5,000 psi. Write: Accessory Controls & Equipment Corp., Dept. M/R, 146 Willard Ave., Newington, Conn.

ANALOG-DIGITAL CONVERTER

An 8-ounce digitizer for converting analog information to binary-coded decimal digital information has been announced.

For use in telemetering to convert meter readings into digital readings for printing on charts at range stations, the device is flexible and permits handling any desired number of decimal digits through addition of modules to the basic assembly.

Measuring 2 11/16 x 2 in., each module added to obtain another decimal place adds ¾ inch to the length. Each module has a code disk and gear train.

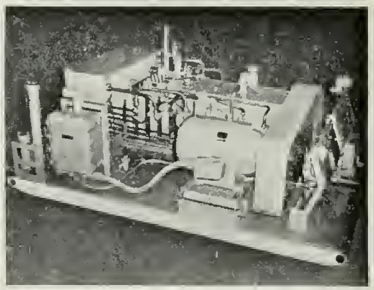
A code and dual brush system is used that eliminates ambiguity. Write: Commercial Sales Dept., Federal Telephone and Radio Co., Dept. M/R, 100 Kingsland Road, Clifton, N. J.

PLUG-IN SWITCH BOARDS

Plug-in circuit boards used in ground support and field test equipment for the Northrop Snark missile permit plugging-in such items as a 12-deck 26-position stepping switch. Switch contacts are produced by etching circuit boards.

The method allows 348 connections to be made simultaneously. Northrop has licensed United Geophysical Corp. to make the new device. Write: Electrodynamic Division, United Geophysical Corp., Dept. M/R, Pasadena, Calif.

COMPRESSION SYSTEM



New "central compression system" developed by Cardox Corp. for testing aircraft and missile pneumatic systems delivers 54 acfm of air with —70°F or lower dewpoint at any needed pressure from 3,000 to 12,000 psi.

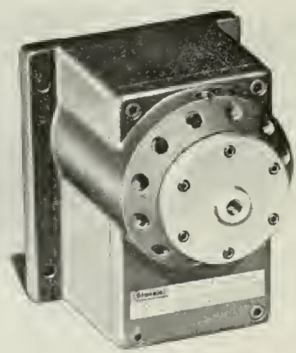
The new system, devised from components used in the coal mining industry for almost 20 years, is said to be operable within a day or two after delivery.

It consists of a semi-portable, self-contained assembly including compressor, 50-hp electric drive, controls, filtering and drying equipment and storage vessels that are mounted on structural steel skids. Write: Cardox Corp., High Pressure Air Div., Dept. M/R, 307 No. Michigan Ave., Chicago 1.

PRESSURE SCANNER

The Datex Model SP-101 pressure scanner introduced by G. M. Giannini & Co. is aimed at lower cost and improved accuracy in pressure instrumentation. It is designed to permit measurement of up to 12 pressure sources with only one transducer.

The SP-101 can be used to automatically introduce calibration or zero pressures during each scan cycle, thereby allowing calculation of exact transducer response and enabling greater accuracy.



Basic unit consists of a stator having 12 input ports and a rotor that connects any one of these to an output port. A unidirectional high-torque motor rotates the rotor to a desired position and built in provisions are available for indication of position either visually or digitally for operation of recording devices.

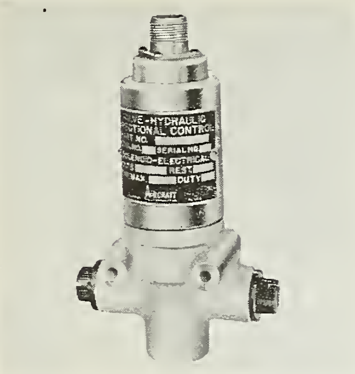
SP-101 operates over a range from 0.1 psia to 350 psig and is usable for dry air and non-corrosive gases. Dimensions are 6⅜ x 5¼ x 5½ in. Write: G. M. Giannini & Co., Inc., Dept. M/R, 918 E. Green St., Pasadena, Calif.

MISSILE HYDRAULIC VALVES

A series of hydraulic accessories developed by Aircraft Products Co. for 3,000-psi missile and aircraft systems includes two-way, three- and four-way shut-off and selector valves and low-leakage sequence valves.

Series 6100 and 6200 two-way, solenoid-operated shut-off valves weigh 1.40 and 1.47 lbs. respectively and employ a balanced, inverse poppet said to allow a wide range of flows and pressures in either direction. Available sizes are adapted to ¼, ⅜ or ½-in. line installations.

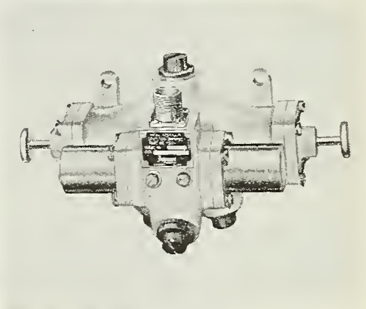
APC's Series 6000 three-way selector valve is designed to handle flows up to 6 gpm through ¼ or ⅜-in. tubing compared to 3.2 gpm for standard ⅜-in. models. Also solenoid operated, this series weighs 1.5 lbs. for ¼ to ⅜-in. applications and 1.61 lbs. for Series 6050 for ½-in. line installations.



Series 7300 four-way, pilot operated solenoid selector valves are available with a variety of design variations—with or without manual override; three-position, spring centered; two-position, spring offset; three-position detent; with thermal relief; and, with spool and sleeve combinations to meet varying porting needs.

New slide-type sequence valves have a maximum internal leakage of 15 drops per minute but are produced in special models with maximum leakage of only five drops per minute.

Valves are available for ¼ or ⅜-in. tube sizes and are provided with either full flow by-pass or thermal type auxiliary relief valves for cracking pressures ranging from 8 to 4,000 psi. Write: Aircraft Products Co., Dept. M/R, 300 Church Rd., Bridgeport, Pa.

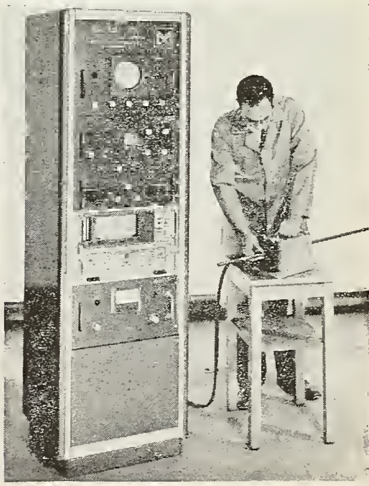


TUBING TESTER

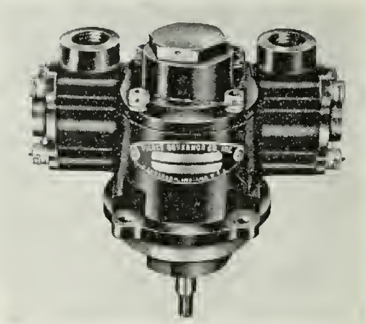
A completely automatic test device for inspecting non-magnetic rod, tubing wire or bar stock has been introduced by Magnaflux Corp.

Called Magnatest FW-400, it locates such defects as overlapping seams, diameter changes, inclusions, voids, metallurgical variation and splits. Unit is designed to handle aluminum, brass, copper, tungsten, austinetic stainless steel and titanium from 1/64 to 3 in. diameter.

FW-400 is available for hand operation in laboratories or for completely automatic, high-speed operation on production lines. Speeds in excess of 150 to 300 fpm can be accommodated. Write: Magnaflux Corp., Dept. M/R, 7300 W. Lawrence Ave., Chicago 31.



FUEL CONTROL UNITS



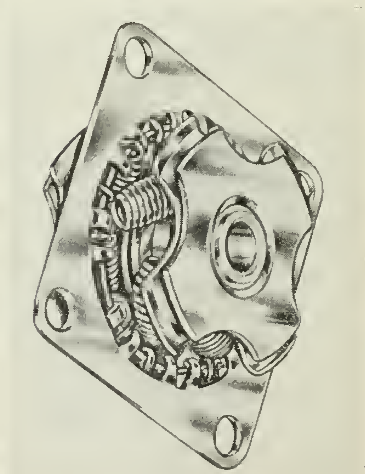
Two new fuel control units for use on turbine-type auxiliary power units and guided missiles have been unveiled by Pierce Governor Co.

New units are basically mechanical type governors with single or dual valve systems. Simple valve units control flow of one fuel, whereas the dual valve type controls and proportions flow of two fuels ranging from JP-4 jet fuel through red fuming nitric acid.

Complete Pierce unit, weighing less than 3 lbs., requires only 0.8 hp input. At speeds of 10,000 rpm, flows of 10,000 pph can be controlled with complete stabilization reached in 0.2 seconds after transit from full open to full closed positions.

Units are adaptable to control fuel flows of 500 to 15,000 pph at higher or lower operating speeds. Write: Pierce Govern Co., Inc., Aircraft Accessories Divs., Dept. M/R, Anderson, Ind.

ALL-METAL MOUNT



New Series 1255000 diagonal spring Equiflex vibration isolator and shock mount marketed by The Ucinite Co. are said to withstand repeated 15g shocks without loss of efficiency and 30g ultimate.

Design features all-metal construction, non-linear spring characteristics, high damping and all-positional or all-attitude performance. Units reportedly withstand hours of resonance with input of .036" double-amplitude per Spec. MIL-E-5272A. Write: The Ucinite Co., Div. of United-Carr Fastener Corp., Dept. M/R, Newtonville 60, Mass.

SOLENOID VALVES

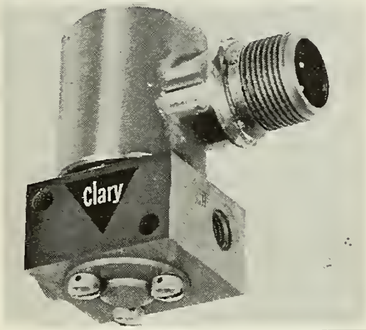
New lightweight solenoid valves designed for guided missile systems measure 2" long by 1" diameter and weigh only 10 oz.

Valves feature a two-in-one operating arrangement whereby they can be operated from either an open or closed position. Changeover from one use to another is accomplished by simple mechanical rearrangement of the solenoid.

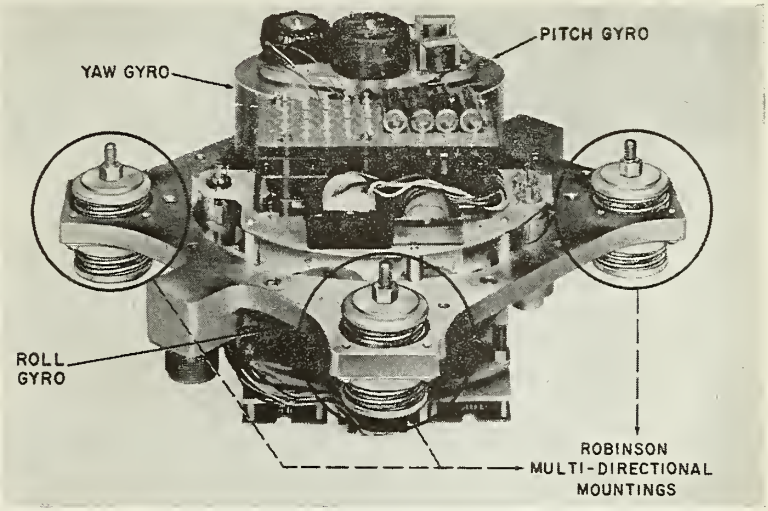
Another feature includes a zero leakage provision made possible by an internal vent to the atmosphere through a controlled outlet which prevents moisture or contaminated air from reaching moving parts.

Valve coil is hermetically sealed and solenoid may be rotated on the valve body to position electrical connector in most desirable location.

Valves are designed for use with air, helium, nitrogen, liquid oxygen or corrosive liquids. Write: Automatic Controls Div., Clary Corp., Dept. M/R, San Gabriel, Calif.



Shockmount for Vanguard



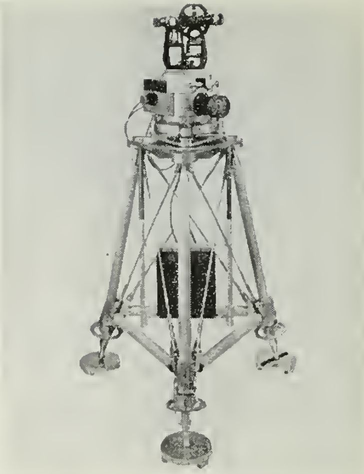
Multi-directional mounting system built by Robinson Aviation, Inc. will protect Vanguard earth satellite's Minneapolis-Honeywell inertial guidance system. Four Robinson Met-L-Flex resilient elements will be attached to the rocket bulkhead with the equipment installed inside. Mounting system is designed to instantly attenuate shock of 6 g or vibration over 65 cps.

THEODOLITE

New azimuth alignment theodolite introduced by Perkin-Elmer Corp. permits alignment of precision missile guidance gyros within an accuracy of 2 secs. of arc.

It is designed to automatically detect gyro alignment discrepancies by continuous observations of reflections from a mirror mounted on a monitored wall. The discrepancies produce error signals which are applied as corrective signals to the drive elements of the gyro.

Components are a dual optical sys-



tem, a mount, and a precision electronic reading system. An upper optical system serves essentially as a precision theodolite, whereas a lower unit consists of two modulated light sources, a telephoto objective, a beam-dividing "Vee" mirror and a photomultiplier tube.

Operation of the system hinges on use of a telephoto lens as a monitoring objective and the reflected beam of a monitored unit's mirror provides the source for indication of alignment condition. If out of alignment, light energy entering a photomultiplier originates an error signal. The phase relationship of the energy is then used to determine direction of error.

Write: Perkin-Elmer Corp., Engineering and Optical Div., Dept. M/R, Norwalk, Conn.

SERVO MOTOR

Smallest standard subminiature servo motor available claims Ford Instrument Co. for its Model SM-58 motor which weighs less than 1 oz. and measures ⅝-in. dia. by 1-in. long.

New motor is proposed for variety of applications in servo systems, computers, indicating systems and missile control systems.

Model SM-58 operates on 26 volt, 400 cycles with a control range of 0 — 26 volts. Other characteristics include 2½ watt input; 1/10 watt output; 0.063 in. oz. stall torque; 8,800 rpm no load speed, and ambient range from —75 to 200°F.

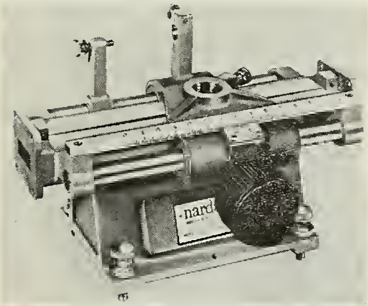
Write: Ford Instrument Co., Div. of Sperry Rand Corp., Dept. M/R, 31-10 Thomson Ave., Long Island City 1, N. Y.

SLOTTED LINES

Six portable slotted lines, Models 319 to 324 that have a carriage drive mechanism integral with the waveguide assembly have been announced. The impedance meters can be used to measure VSWRs and impedances from 2600 to 18,000 mc covering the waveguide sizes from 3 x 1½ inches to 0.702 x 0.391 inches.

The meter is supported by a removable pedestal casting. Residual VSWR is said to be under 1.01 with imperceptible slope and slot leakage.

A mounting hole is provided for use with all standard military and commercial rf probes. Write: John Mather Lupton, Inc., Narda Corp., Dept. M/R, 420 Lexington Ave., New York 17, N. Y.

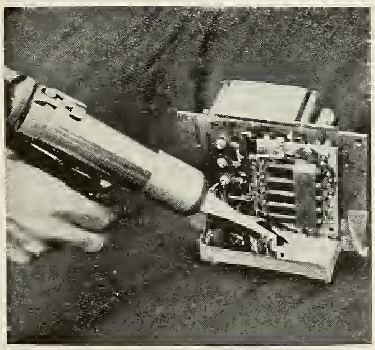


SILICONE RUBBER

A silicone rubber that cures at room temperature has been developed for use in high impedance electronic circuits in missiles.

Coating of component parts in circuits with the new rubber improves resistance to vibration, moisture resistance, surface resistivity and other electrical properties.

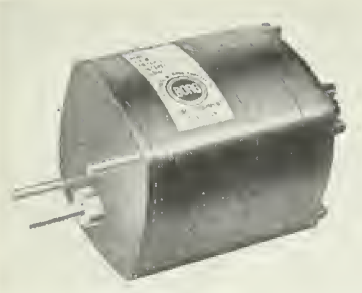
Components may be inspected by slitting the rubber after application, and then patching. Application is with a gun at about 100 pounds pressure. The material is being used in the Snark missile. Write: Dow Corning Corp., Dept. M/R, Midland, Michigan.



SUB-FRACTIONAL HP MOTORS

Series of sub-fractional horsepower motors introduced by George W. Borg Corp. are rated in the range from 1/2000-hp to 1/750-hp for precision instrument use.

Designs feature end bells and gear train cases of die-cast alloys that are precision machined to form a totally enclosed housing. Available types include synchronous and induction motors,



with or without gear trains. Write: George W. Borg Corp., Borg Equipment Div., Dept. M/R, Janesville, Wisc.

GAS GENERATORS

Pre-packaged gas generators, produced by McCormick Selph Associates to make explosive power widely available, can provide power for pressurization of fluids, ignition of liquid propellants, operation of turbines and actuation of pistons and expandable rings.

The units are capable of creating a known amount of gas at predictable pressures and temperatures for a given time and it is said that they are insensitive to vibration and acceleration due to the absence of moving parts.

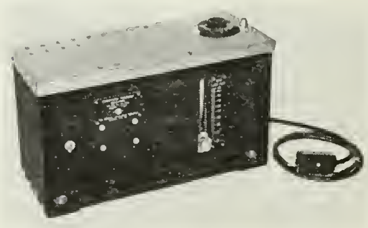
Included as part of the generators or as separate sub-assemblies are electrical squibs, and electrical connections can be made by leads or by quick-connect plug and receptacle combinations.

Horsepower ranges from 0.01 to 150 and output pressures from 15 to 25,000 psi. Write: McCormick Selph Associates, Dept. M/R, 15 Hollister Airport, Hollister, Calif.

VIBRATION TESTING MACHINE

The Model 14-28 Vibration Testing Machine, developed for vibration testing of small items, is said to be small and lightweight with widely variable amplitude and frequency.

Product of the Ahrendt Instrument Co., the machine has a cast aluminum base and weighs 30 lbs. Dimensions are 15½ in. length, 6 in. width and 9 in. height.



Write: The Ahrendt Instrument Co., Dept. M/R, 4910 Calvert Rd., College Park, Md.

DISC-TYPE THERMOSTAT

A miniature, Klixon, snap-acting thermostat especially recommended in aircraft controls and guided missiles has been developed by the Spencer Thermostat Division of Metals & Controls Corp.

The C7216 unit features the Spencer Disc thermal element, silver electrical contacts, a hermetically sealed assembly, and is protected from moisture by a copper nickel-plated casing.

Fixed temperature settings range from —20°F to 400°F.

Write: Metals & Controls Corp., Spencer Thermostat Div., Dept. M/R, Attleboro, Mass.

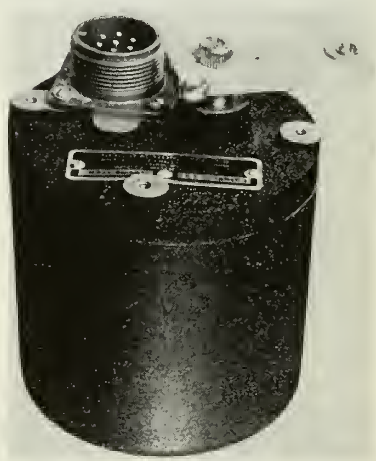
MOTOR-GEAR-TRAIN

High torque, low speed and wide temperature range combined with smaller size are the unusual features claimed for a new motor-gear-train designed by John Oster Mfg. Co. Only 2.8 in. long, the size 18 torque is 25 oz.-in. at 1.7 rpm unloaded and operates in temperatures as low as —55°C.

Type 5602-02 uses a single phase capacitor or 2-phase servo motor and is rated for continuous duty at 115V 60 cycles.

Write: John Oster Mfg. Co., Dept. M/R, Avionic Div., Racine, Wisc.

SERVO ACTUATOR



White-Rodgers Co. has announced a D-9 permanent magnet type rotary servo actuator designed for continuous operation at an output rating of 70 inch-pounds at 8.5 rpm.

The servo, which the company says meets applicable military specifications, features limit and centering switches and potentiometer for feedback of position information.

Weight of the unit is 1.9 lbs., diameter is 3 5/16 in. and overall length is 4⅞ in.

Write: White-Rodgers Co., Dept. M/R, 4407 Cook St., St. Louis 13, Mo.

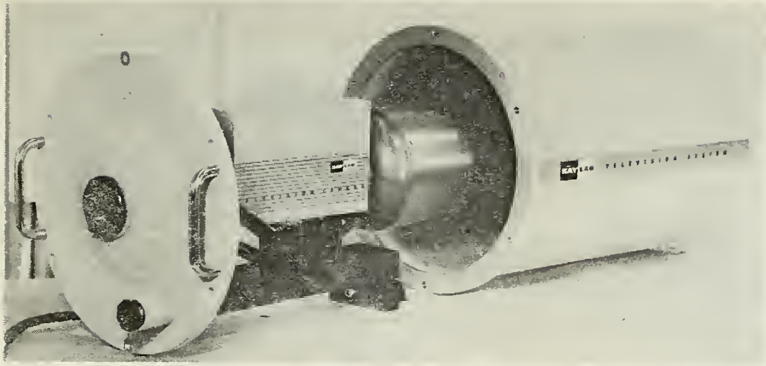
FLUSH LATCH

An improved flush latch with specially designed rubber gaskets for better latch sealing characteristics has been reported by the manufacturer, Missile-Air.

Self-sealing is accomplished by rubber gaskets which are fuel-resistant and surround "push" and handling buttons at access doors and panels. These Series 1100 units have over-center toggle action, weigh only one ounce and are available for all door and offset thicknesses.

Write: Missile-Air, Dept. M/R, 1616 West 134th St., Gardena, Calif.

RUGGEDIZED CAMERA



A new ruggedized camera developed by Kay Lab for rocket and jet engine test facilities and rocket launching sites has been designed for high-noise applications.

The camera combines with another new development, an acoustical housing, which provides about 45 db of isolation. Housing is arranged to accept the remote iris-focus, auto-zoom lens and three-lens turret accessories for the camera.

In tests with the equipment at rocket firing sites, performance was reported trouble-free at locations where sound levels well over 150 decibels had previously been measured.

The new combination camera and housing is expected to make possible the use of television in many applications where such equipment previously could not be employed due to high noise conditions. Write: Kay Lab, Dept. M/R, 5725 Kearny Villa Rd., San Diego 11, Calif.

ACCELEROMETERS

A new line of accelerometers, pressure pickups and force gages using piezoelectric materials has been announced. Change in sensitivity over a temperature range of —65 to 230 degrees F is less than 10 percent, according to the manufacturer.

High sensitivity is maintained at 10mv/g. Natural frequency is 35 kc, and a high g range of 10,000 is handled.

Information is available in Bulletin 803. Write: Endevco Corp., Dept. M/R, 161 California St., Pasadena, Calif.

missile literature

TEMPERATURE CONTROLS. Six-page brochure MC-132 gives physical dimensions, current ratings, temperature ranges and other characteristics of miniaturized temperature controls for missiles and related applications. Write: Fenwal Inc., Dept. M/R, Ashland, Mass.

INSTRUMENTS. A 31-page general catalog gives specifications, descriptions and illustrations of instruments for analysis, control and data processing. Write: Consolidated Electrodynamics Corp., Dept. M/R, 300 North Sierra Madre Villa, Pasadena, Calif.

OSCILLOSCOPES. Quick reference catalog of a complete line of oscilloscopes, large screen cathode ray tube indicators, electronic test instruments, and equipment for photo-recording. Write: Allen B. DuMont Laboratories, Inc., Technical Sales, Dept. M/R, Clifton, N. J.

PRINTED CIRCUITS. A 15-page brochure covers processing and materials data used in making printed circuits. Step-by-step information is given together with the characteristics of various base materials. Write: Formica Corp., Dept. M/R, 4617 Spring Grove Ave., Cincinnati 32.

POWER CONVERTERS. A 4-page brochure, catalog 56P, describes newly developed ac-dc converters using semiconductor devices to replace vibrator or dynamotor conversion. Test is directed to designers of missiles and airborne systems where operating environments are a problem. Write: Power Sources, Inc., Dept. M/R, 8 Schouler Court, Arlington, Mass.

people

Thomas B. Carvey, asst. head of the design integration department, has been appointed head of the launchers and powerplants department of Hughes Aircraft Co.'s guided missile laboratories. **John W. Withers** will succeed **Carvey** in the design integration post. **Dr. Morris Feigen** has been named senior staff engineer of the design integration dept. **Michael E. Hiehle** has been named project manager for the weapon systems development laboratories. **John R. McCharles** and **Alexander S. Jerrems** were named asst. directors of Hughes' fire control systems laboratories.


Carvey

John E. Lowe, formerly personnel mgr. of American Machine & Foundry Co.'s electronics division, has been appointed director of personnel and public relations of the company's new guided missile launching system plant in Rochester; **U. W. Richardson** has been named defense products mgr.

Autonetics (a division of North American Aviation, Inc.) engineering is now headed by the following persons: **J. C. Elms**, armament control; **D. L. Williams**, flight control; **D. B. Wright**, flight test; **S. F. Eyestone**, guidance; **E. A. Holmes, III**, reliability and standards; and **G. D. Shere**, data process equipment.

David L. Grimes has been appointed president of Narmco, Inc., manufacturer, among other things, of aircraft and missile components.

Edward Hartshorne has been named gen. mgr. of the nuclear fuel division of Olin Mathieson Chemical Corp.

J. S. Warfel is manager of Aerojet-General Corp.'s new Avionics Division, formerly known as Electronics and Guidance Division.

Dr. John L. Miller, director of defense activities for The Firestone Tire & Rubber Co., has been named deputy chairman and a member of the National Council of the Artillery Division of the American Ordnance Assn., in addition to his position as deputy chairman of the Guided Missile and Rocket Division.


Miller

The following persons have recently joined the staff of the Applied Physics Laboratory of the Johns Hopkins University: **Thomas S. Mortimer**, **Kenneth W. Howard, Jr.**, and **Herndon H. Jenkins, Jr.**, associate engineers, and **George Gebel** and **Jacob L. Herson**, engineers. The Laboratory is engaged in guided missile research and development.

Roger A. Burt has been appointed manager of the systems analysis section of Electronic Control Systems, Inc., an affiliate of Stromberg-Carlson and a subsidiary of General Dynamics.

Lawrence G. Haggerty has been elected president of Farnsworth Electronics Co. **P. E. LaLiberte** has been

appointed sales manager for weapon control equipment for General Electric's light military electronic equipment department.

Rod Koutnik has joined the automatic controls division of Clary Corp.

George F. Metcalf has been named general manager of General Electric's new missile and ordnance systems department.

Dr. George Roka has been named director of the semi-conductor division of Marvelco Electronics Division, National Aircraft Co.

L. S. Preston has been appointed chief engineer of the Electronic Engineering Co. of California; **D. R. Proctor** will be his assistant.

Brig. Gen. Howell M. Eates, Jr., asst. deputy commander for weapon systems at ARDC's Detachment No. 1 at Wright-Patterson AFB, has been promoted to major general. This detachment manages the development of USAF missiles and aircraft weapon systems.

Under a major reorganization, Bell Aircraft Corp's Niagara Frontier Division will be discontinued and its activities will be divided into two new divisions—the Aircraft Division headed by vice president **Julius J. Domonkos** and the Weapons Systems Division headed by vice president **Roy J. Sandstrom**. The Weapons Systems Division will be subdivided into four units: Avionics, **John H. van Lonkhuyzen**, mgr.; Rockets, **William M. Smith**, mgr.; Guided Missiles, **Jesse H. Zabriskie**, mgr.; and Research, **John F. Strickler**, Jr., mgr.

Domonkos

Edwin H. Meier, head of the Hughes Aircraft Co.'s guided missile engineering laboratories at Tucson, and **Frank G. Miller**, head of the systems engineering department in the guided missile laboratories at Culver City, have exchanged positions.

Henry A. Boguslawski has been elected vp-engineering sales for Rocke International Corp.; **M. M. Riise** (Cmdr. USN, ret.) has been named exec. asst. to the president. **Boguslawski** was formerly associated with RCA; **Mr. Riise** was with Sperry Rand, in operations for the Defense Department's missile program and guidance system.

Allan W. Jayne will head Gabriel Electronics Division's research and development activities at the Gabriel Company, Needham Heights, Mass. **Dr. Richard J. Burke** has been named head of Lockheed Aircraft Corp.'s Missile Systems division's telemetering department.

David P. Coffin, Jr. has been appointed chief of Hoover Electronics Co.'s Engineering Department, defense projects section; **Robert P. Wehrmann** will head the telemetering section.

Dr. Robert E. Buchele has been named staff assistant to the Western Division manager of Servomechanisms, Inc. **Dr. Earl L. Steele** was appointed chief engineer of the development department, Semiconductor Products Division, Motorola Inc.

Warren E. Milner was appointed to the newly created position of mgr. of the Milwaukee plants of AC Spark Plug Division of General Motors.

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Sperry, Alcoa Sign Wage Agreements

Sperry Gyroscope Co., division of Sperry-Rand Corp. has reached agreement with International Union of Electrical Workers on a 4-year pact covering 9,500 employes. It provides a 5¢ per hour pay increase and a cost of living adjustment of 2¢ an hour effective November 1.

Aluminum Co. of America and United Auto Workers signed a 3-year, no-strike contract providing benefits of about 46¢ an hour over the three years. It covers about 4,200 UAW members at Alcoa plants in Garwood, N.J.; Vernon, Calif., Chicago and Cleveland.

Ex-Northrop Official Forms New Firm

Cybergor, Inc. has been organized under president J. J. Gorman, former Northrop budget director, as a new source of magnetic materials. D. F. White, until now chief engineer of Marchant Research Corp., is v.p.-engineering.

New company is specializing in ferrites and grain-oriented silicon and nickel steel toroids. Offices are at 1705 W. 135 St., Gardena, Calif.

P&W Employment Drive At Half-way Mark

A drive by Pratt & Whitney Aircraft division of United Aircraft Corp. to add 3,000 technicians to its payroll by December 31 has reached the midway point, according to company officials.

P&W payroll in October moved beyond 38,500 toward a goal of 40,000 by the year end. Employment drive is aimed at virtually all job categories—machine operators, tool and die makers, sheet metal, welding and assembly technicians, engine test house operators, mechanics and inspectors.

Its current missile activity includes production of J57 engines for the Northrop *Snark*.

Marquardt, Bendix Get Tax Write-offs

Marquardt Aircraft Co. has been granted an accelerated tax amortization of 60% by Office of Defense Mobilization covering new $3,295,475 facility at Ogden, Utah.

Bendix Products Div., Mishawaka, Ind. was granted a rapid tax write-off at 40% for new missile facilities valued at $316,275.

Avco Leases Denver Office

Avco Manufacturing Corp. has leased 3,000 sq. ft. of office space in the Mile High Bldg., Denver presumably in connection with its ICBM nose cone development work.

Avco is one of two firms working on the critical nose section for the *Titan* missile which Martin will build near Denver.

The company expects some 35 employes will be assigned there.

Aerojet Sets Up Nuclear Department

Aerojet-General Corp. has established a Nuclear Projects Department at its Azusa, Calif. plant in a move to promote application of nuclear science and engineering to its rocket engines and other developments.

New office is headed by D. A. Young, asst. chief engineer of Aerojet's Liquid Engine Division.

Navy Lets $31 Million Contracts for *Sidewinder*

Navy last month let two new contracts totaling $31 million for production of guidance and control units for its *Sidewinder* air-to-air missile.

An award of $17 million went to General Electric Co. and another for $14 million to Philco Corp.

West Coast Gets New Electronics Firm

Dr. J. V. N. Granger, former head of Stanford Research Institutes radio systems laboratory, has formed Granger Associates, a new California corporation for development and production of aircraft electronics equipment.

In addition to Granger as president, other officers are R. M. Leonard, secretary, and R. J. Halk, treasurer. Temporary offices are at 801 El Camino Rd., Menlo Park, Calif.